A STUDY OF THE EFFECT OF RESIN FINISHES FOR CREASE RESISTANCE

UPON THE SERVICEABILITY OF CERTAIN COTTON FABRICS

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CHAPTER I

INTRODUCTION

One of the greatest advances in the cotton textile industry of recent years has been the development of a process for obtaining crease resistant fabrics by resin applications. This is a relatively new process that is being received by the consumer and the industry with interest. However, many questions are being voiced in regard to the durability of the finish and the serviceability of such treated fabrics.

Prior to the development of this finish, consumers had objected to the lack of elasticity in cotton and linen fabrics that caused garments to wrinkle easily and to lose their desired shape and appearance. For this reason, garments of the more resilient fabrics were often selected in preference to the easily crushed cotton and linen garments. This problem has been of much concern to the textile industry. Manufacturers of cotton were particularly concerned; for during 1949, cottons comprised 69 per cent of the textile market in the United States with an annual output of roughly ten billion yards.[1]

It has been determined that the range of usefulness of cotton fabrics can be extended by treatment with resins to improve their resistance to wrinkling. After application of these finishes, the fabrics will not crush so readily and will recover more quickly from

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[1] "New Finishes For Old Fibers," Fortune, 39: 121, April 1949.

crushing than will untreated fabrics of the same type. Consequently, the garments appear fresher during wear and require less pressing. Because of the nature of the finish, soil does not penetrate the fiber as readily, but tends to remain upon the surface of the fabric. Laundering is easier as the soil is released with milder laundering action and with lower water bath temperature. The resilience imparted by the finish permits the fibers to spring back into their original position after washing, thereby preventing the formation of deep wrinkles that make ironing difficult. As crease resistance is obtained, starching is unnecessary.

These advantages are of great value to the consumer as well as enabling cotton fabrics to better meet the competition of the newer synthetic fibers.

Although the wrinkle resistant finish was first introduced in the United States in 1933,[2] its use has been accepted slowly and was applied to fabrics of rayon and linen before being applied to cottons. Dan River Mills, one of the south's largest dress goods manufacturers, first applied the resin treatment in volume to cotton fabrics in 1947.[3] By 1949, only five per cent of the yardage produced by this company was resin treated.[4] Of all the cotton fabrics manufactured throughout the United States in 1949, only one per cent was resin treated.[5] This,

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2 Shapiro, "Urea Formaldehyde Resins for Textile Finishing" Reprinted from Rayon and Synthetic Textiles, July, 1949.

3 "New Finishes For Old Fibers," Fortune, 39:132, April, 1949.

4 Ibid. p. 132.

5 Ibid. p. 132.

of course, included cotton fabrics of all types, whereas the major potential for crease resistance is in apparel fabrics.

Because of the newness of the treatment and the constant changes that the process is undergoing, research is needed to indicate the effects of the treatment upon fabric serviceability. There has been a great amount of technical research applied to the development and perfection of the crease resistant processes, but only a limited amount of research has been directed to the serviceability that the consumer might expect of treated fabrics.

Opinions vary in regard to the effect of the resins upon the fiber properties. One resin manufacturer stated that the effect of the resin upon the life of the garment is negligible, although he acknowledged that earlier processes had reduced the tensile strength of treated fabrics.[6] A textile manufacturer declared that the wrinkle resistance of his treated fabrics improved with age and use.[7]

In contrast to the claims of manufacturers, it has been generally accepted by persons in textile research that the application of resin finishes has produced some undesirable changes in fabric properties. Most fabrics creaseproofed by resin impregnation have the drawback of showing a harsh hand and poor draping qualities. Research has indicated that the tear and breaking strength of treated fabrics decreases as the amount of crease resistance increases; but the results of research conducted by fabric manufacturers and resin producers are

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6 "Process Cuts Wrinkling In Cotton Fabrics," Business Week, p. 43, September 6, 1947.

7 Ibid.

seldom made available to the consumer.

Consumers want to know the resistance of treated fabrics to wrinkling and the extent of the retention of anti-crease properties after laundering and wear. Of equal interest to the consumer is the effect of resin treatment upon fabric strength and wear properties as they influence garment serviceability.

The crease resistance obtained by resin impregnation is not as satisfactory as the natural resilience that is present in silk and wool fibers. Through studies that will indicate the shortcomings of present methods, other research can follow that will lead to the development of better crease resistant processes. Research projects that present the consumers' opinions of the serviceability of certain resin treated fabrics should contribute information that is needed to further the development and perfection of crease resistant processes.

It was the purpose of this study

1. To compare the original crease resistance and strength properties of treated and untreated cotton fabrics of the same construction,

2. To determine the adaptability of resin treated fabrics to garment construction,

3. To determine the serviceability of treated and untreated fabrics made into garments and subjected to usual wearing and laundering conditions,

4. To determine the extent of the retention of the crease resistance properties and the changes in strength after laundering and wear of resin treated fabrics,

5. To compare the dimensional stability of treated and untreated fabrics after laundering, and

6. To compare the serviceability of treated and untreated fabrics as determined by laboratory laundering and testing.

In the ensuing chapter, studies and information related to the history and development of resin treatments for crease resistance are reviewed. Following the review of literature, the methods used in securing the test fabrics, selecting the garment styles, constructing the garments, and planning for the wear study are stated. Procedures for the laboratory analysis of fabrics, the laboratory laundering formula, and the laboratory tests performed upon the fabrics are included. Results of the wear study and of the laboratory tests are given in the following chapters and are presented in table and graphical form where possible. The final chapter contains a summary of the findings, the conclusions reached, and recommendations for further study. All record and report forms related to the wear study are included in the appendix.

CHAPTER II

REVIEW OF LITERATURE

Development of Crease Resistant Procedures

In 1929, thirty members of the Tootal, Broadhurst, and Lee research staff announced that cellulose fibers could be made crease resistant by a process utilizing two common resins - phenol formaldehyde and urea formaldehyde.[1] Phenol formaldehyde gave good results except for the tendency to discolor and to give the fabrics an odor of carbolic acid, which eliminated its use for clothing. Urea formaldehyde was suitable for treating rayons, but did not give satisfactory results for cottons and wools. A resin suitable for cotton, melamine formaldehyde, was developed in this country by Monsanto Chemical Company and American Cyanamid Company.[2] Today, most finishers are using the more expensive melamine resins, which produce about twice as much wrinkle resistance per ounce of resin as that produced by compounds formerly used.[3] Such compounds make treated fabrics resistant to water and alkali, yet they allow the fabrics to breathe.[4]

The general classes of resin forming materials are:

"Thermoplastic, thermosetting, with a subdivision of the latter which might be called reactants.

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[1] "New Finishes for Old Fibers," Fortune, 39:124, April, 1949.

[2] Ibid, page 126.

[3] Loc. cit.

[4] Sherman and Sherman, The New Fibers, New York: D. Van Nostrand and Company, Incorporated, 1949, page 321.

The thermoplastic types available today are completely polymerized at the time of manufacture. That is, the chemical manufacturer takes a small molecule (......) and polymerizes it to form the large polymer. Because of the large size of the polymer, it cannot diffuse into the fibre; and therefore gives only surface effects such as bodying and stiffening; and because it is already completely polymerized, no cure is necessary.

The thermosetting types, on the other hand, are purchased in the monomeric or the partially polymerized form. They are applied generally with a catalyst, and given some heat treatment in addition to the drying step. The monomer form is quite reactive; it should be kept in a cool place, and applied from the cold solution. This keeps it monomeric, so that it diffuses completely into the fibre, giving internal effects such as creaseproofing. The partially polymerized forms are less easily diffusible and usually give surface effects, such as stiffening, with comparatively little creaseproofing.

Finally, there is a type of material which we might call a reactant because when such a compound is applied to cotton or rayon, it will more readily react with the cellulose than it will react with itself. Reactants give a soft hand because of the lack of surface resin, and are largely used for stabilization of rayon."[5]

To produce crease resistance in fabrics, a compound must form cross linkages and must be diffusible into cellulose.[6] If it is not monomeric, it will not diffuse through a cellulose membrane, and will not change the stress strain properties of the fibers. As a result, the resin will be deposited only on the surface of the fabric, and crease resistance will not be produced.[7] The most effective compounds for resin impregnation consist of urea and formaldehyde or various amines or amides and formaldehyde.[8]

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[5] A. C. Neussle, "The Practical Application of Synthetic Resins to Cellulose Textiles," Reprinted from the Canadian Textile Journal, December 23, 1949, p. 3.

[6] D. D. Gagliardi and I. J. Gruntfest, "Creasing and Creaseproofing of Textiles," Textile Research Journal, 20: 184, March, 1950.

[7] Ibid, page 184.

[8] Loc. cit.

The application of resin finishes consists of a series of operations. The cloth is prepared for the process by thorough scouring and desizing to remove all alkali or salts which might retard the curing operation. After cleansing, the fabric is dried to a moisture content varying from five to ten per cent so that the fabric will be more receptive to resin penetration.[9] The fabric is completely wetted with an aqueous solution containing the resin precondensate and latent catalyst, which is usually an organic or inorganic acid that is neutral in solution but becomes acidic during the curing operation. Ammonium salts of strong inorganic or organic acids are most often used. At high temperatures, the ammonia is driven off, and the goods becomes acidic.[10]

The reaction takes place at carefully controlled temperatures and pH.[11] Up to a certain point, the solution remains soluble in water. As the reaction continues, the basic chemical unit or monomer combines with itself to form larger molecules that are insoluble in water, but soluble in organic solvents.

The fabric is padded and squeezed tightly to drive the resin into the fibers. The fabric is usually frame dried and cured at an elevated temperature for a definite period of time, usually from five

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[9] Leonard Shapiro, "Crease Resistant Finishes with Urea Formaldehyde Resins," Reprinted from Rayon and Synthetic Textiles, July, 1949.

[10] Leonard Shapiro, "Urea Formaldehyde Resins for Textile Finishing," Reprinted from Rayon and Synthetic Textiles, August, 1949.

[11] Loc. Cit.

to seven minutes.[12] Undercuring will cause poor resin fixation, poor quality of crease resistance, and poor durability to laundering. Overcuring may result in the breakdown of the resin, odor development, and some damage to the fabrics.[13] After curing, the fabric is washed in a detergent solution containing soda ash to remove the excess resin and to neutralize the acidity.[14] The fabric is then redried.

If stabilization is the objective of the resin treatment, the fabric should be processed under slight tension up to the time of cure. After curing, the fabric should be relaxed. This results in a fabric that is shrinkproof and fairly crease resistant. When creaseproofing is the main concern, the fabric should be processed in a relaxed condition to permit adequate resin penetration.[15]

Effect of Crease Resistant Finishes Upon Fiber and Fabric Properties

Aenishaenslin[16] found that different effects are produced with urea and melamine resins according to the type of precondensate used. Three precondensates, water soluble dimenthylol urea in powder form,

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12 Leonard Shapiro, "Crease Resistant Finishes with Urea Formaldehyde Resins," Reprinted from Rayon and Synthetic Textiles, July, 1949.

13 A. C. Neussle, op. cit., page 6.

14 Leonard Shapiro, "Urea Formaldehyde Resins for Textile Finishing," Reprinted from Rayon and Synthetic Textiles, August, 1949.

15 A. C. Neussle, op. cit., pp. 5-6.

16 R. Aenishaenslin, "The Influence of Urea and Melamine Resin Finishes on the Mechanical Properties of Cotton Fibers," American Dyestuff Reporter, 40:432, July 9, 1951.

dimethylolmelamine in powder form, and syrupy, metholylolamine methyl ether of 73 per cent solid content were applied to unmercerized cotton. With all three precondensates, the application and curing processes were controlled so that the treatment would be identical. Aenishaenslin's study revealed that

> "the greatest loss of strength occurred in goods finished with dimethylolurea. The crease resistance and anti-swelling effects are approximately equal in the case of all three resins. The question as to why a marked lasting weakening of fiber resulted only when urea resins are used cannot be answered with any degree of certainty. We surmise that the very weakly basic urea resins are unable to buffer the excess of catalyzer whereas the more strongly basic melamine resins are obviously able to do so."[17]

The basic chemical unit of cotton is $C_6H_{10}O_5$. These molecules appear in long chains or linear polymers in numbers varying from several dozen to several thousand and are linked end to end. Extending from these chains are hydroxyl groups, which have an affinity for water. Wrinkling is caused by these hydroxyl groups absorbing moisture, thereby causing changes to occur in the fabric and fibers.

The cotton fibers will not absorb much moisture, from 7 to 20 per cent of their weight, depending on the humidity.[18] The resin in the water solution will only go where the water will go. Exceeding the fiber absorption limit causes an increase in the amount of resin deposited in or between the fibers. This deposit alters the feel and

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[17] *Loc. cit.*

[18] "New Finishes for Old Fibers," *op. cit.*, page 126.

general appearance of the fabrics, usually making them springier and harsher to the touch.[19] The crease resistance is produced by that resin penetrating the fibers.

The yarn and fabric construction influence the absorption of the resin, and therefore, have a decided effect upon the properties of the wrinkle resistance produced.[20] Resin applications reduce the moisture pickup and swelling of fibers by the development of cross linkages or the blocking of the hydroxyl groups in the cellulose molecules, thereby reducing the wrinkling tendencies.[21]

The nature of the attachment of the resin to the fibers seems

> "to involve the formation of cross linkages between the adjacent cellulose molecules. The formation of such linkages reduces the extent of internal molecular slippage, which is responsible for the creep or plastic flow at high stress applications, and increases the Hooke's law regain in the fibers, that is, the amount of true elasticity (......). Thus, it would seem that increasing the elastic recovery of cellulose fibers produces fabrics which have a high degree of wrinkle resistance. It should be noted also that one other effect produced by the chemical modification is the increase in modulus, i. e., the fibers become stiffer (......). Improvements in crease resistance of the fabrics closely parallel the improvement previously noted in the fiber elastic recovery and the increase of modulus or fiber stiffness (......). Increase in fiber stiffness is also an important factor in obtaining high resistance to creasing. The stiffer fibers not only will better resist the action of bending stresses; but also in the formation of a close fold in the fabric, such fibers can more readily adjust themselves to a position of minimum strain than can limp fibers. While this increase in modulus appears to aid in producing resistance to creasing, at the same time the higher modulus produces lower resistance to abrasive action and lower resistance to ripping and tearing forces."[22]

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19 Loc. Cit.

20 Marie Falcone, "Wrinkle Resistant Finishes," Rayon and Synthetic Textiles, 32:53 .August, 1951.

21 "New Finishes for Old Fibers," loc. cit.

22 Gagliardi and Gruntfest, "Creasing and Creaseproofing of Textiles," Textile Research Journal, 20:183, March, 1950.

The improvement in anti-creasing is usually accompanied by a loss of strength in goods. In general, the loss appears to be related to the wrinkle resistance produced.[23]

Marsh states that a decrease in apparent breaking load of resin treated cotton fabrics may vary from five to fifteen per cent. This decrease is usually in the filling direction rather than the warp direction.[24]

The reduction in tear and abrasion values results from reduced fiber extensibility rather than cellulose degradation. Proof that the cellulose is not hydrolyzed or oxidized by treatment may be found in reversing the action that takes place in curing. The original fabric properties are restored.[25]

Thorough fabric preparation to produce absorbent goods is important in helping to maintain tensile strength and tear strength properties. Acid catalysts have little to do with changes in fabric strength; but losses of strength are determined by the amount of resin fixed within the fibers.[26] A higher ratio of formaldehyde to urea is most effective for creaseproofing but causes the greatest embrittlement of the fibers, which is responsible for the loss of tensile strength

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[23] R. F. Nickerson, op. cit., p. 46.

[24] J. T. Marsh, An Introduction to Textile Finishing. New York: John Wiley and Sons, Incorporated, 1951, p. 414.

[25] A. C. Neussle, op. cit., p. 6.

[26] A. C. Neussle, op. cit., p. 5.

and abrasion resistance.[27] There is a progressive decrease in tensile strength with the increase of formaldehyde content in the resin.[28]

Fiber length, yarn count, twist, fabric construction, and weight of fabrics are of importance in their effect upon the strength changes of resin treated fabrics.[29]

"The effect of fabric construction on tear strength is very important, but where a standard fabric is desired to be resin treated without changing construction, a somewhat different approach is required to obtain maximum tensile and tear strength. This involves the use of the minimum possible amount of resin; and this, in turn, is governed by the degree of wrinkle resistance obtained for consumer satisfaction in actual use."[30]

Wear tests on treated dress goods indicate that an angle of 90 to 100 degrees will produce the amount of crease resistance that will be satisfactory to the consumer.[31] Too much crease resistance is undesirable because of the difficulty encountered in pressing seams and hems flat, and in making fabrics pleat. Too much crease resistance is also undesirable because of the severe loss in tensile strength and tear strength.

Nickerson[32] controlled the laboratory application of resin to 80 x 80 unbleached, unmercerized, and unfinished cotton fabric. A number of variables of the resin application were separately varied to determine the influence of different variables on fabric properties.

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27 Leonard Shapiro, "Crease Resistant Finishes With Urea Formaldehyde Resins," Loc. Cit.

28 Loc. cit.

29 Ralph Fischer, "What's Cooking in New Resin Treatments," Textile World, Vol. 100: 190, June, 1950.

30 Loc. cit., p. 192.

31 Ralph Fischer, op. cit., p. 190.

32 R. F. Nickerson, "Investigation of Anticrease Treatments for Cotton," American Dyestuff Reporter, 39: 46, January 23, 1950.

Results of the tests revealed that fabric properties are more dependent upon the temperature of the cure than upon the time of the cure. Nickerson concluded that

> "Larger and larger amounts of resin cured at higher and higher temperatures should favor cross linking and do indeed produce greater and greater crease angles. However, the reduction in fiber stretch which accompanies this cross linking is probably the primary cause of strength and tear losses. For this reason, strength and tear vary inversely with the crease angle.(.....) Apparently, there is little change in hand and effectiveness due to washing after the first severe wash test. Thereafter, the wrinkle resistant qualities remain about the same throughout numerous launderings."[33]

Margaret Furry[34] subjected twenty cottons, linen, and rayon fabrics of linen like appearance and resin treated for crease resistance to laundering tests. A mild washing formula using the hand wash and a neutral soap was used as well as a more severe wash test using a washing machine and a soap containing soda ash. The fabrics were laundered and ironed for five times. All fabrics lost some resilience in laundering, with more loss resulting from the severe wash than from the mild wash test. The greatest loss occurred in the linen fabrics. Cotton lost about the same resilience with the mild and severe tests, but was slightly more resilient after the milder laundering. In the warp direction, cotton lost 25 to 30 per cent and the filling lost 12 to 14 per cent resilience. All fabrics had greater strength in the warp than in the filling direction. Shrinkage for the

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33 Ibid. p. 49.

34 Margaret Furry, "Crease Resistant Fabrics," Journal of Home Economics, 31:241-2, April, 1939.

cottons and linens was under 2 per cent, although few of the fabrics were labeled preshrunk.

Other tests have revealed that resin compounds will stabilize fabrics against shrinkage during laundering. Shrinkage is not entirely eliminated, but there is a reduced tendency toward dimensional changes. Warp shrinkage is usually more than filling shrinkage.[35]

Marsh states that if resin treated fabrics are washed at a low temperature of 50 to 60 degrees centigrade, the effects of creaseproofing should remain for twenty five or more launderings. The small amounts of loose resin on the fabrics are usually removed in the first two or three washings.[36]

Some resin treated fabrics retain chlorine when bleached with chlorine freeing compounds. In small amounts, the retained chlorine is harmless; but greater amounts show up as yellowing or as tensile strength losses when the fabrics are ironed. When urea and melamine resin treated fabrics are subjected to mild chlorination, no harmful effects result. However, the margin of safety is rather small. With increased hypochlorite concentrations and inadequate rinsing, considerable damage may result. The modified urea resin types offer more resistance to overdoses of bleach or to other factors that would result in damage to fabrics of the usual type of resin treatments.[37] Fischer[38]

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[35] J. T. Marsh, op. cit., pp. 419-20.

[36] J. T. Marsh, op. cit., p. 425.

[37] A. C. Neussle and J. J. Bernard, "Some Aspects of Chlorine Retention by Resin Treated Fabrics," American Dyestuff Reporter, 39:403, June 12, 1950.

[38] Ralph Fischer, op. cit., p. 192.

says that the newer melamine resins are not decomposed by normal ironing temperatures and that many cotton fabrics are found to have less loss of tensile strength after treatment with the newer type resins.

The dyeing of fabrics is altered somewhat by resin treatments. Creaseproofed fabrics develop an immunization to direct dyes, due to the development of cross linkages which prevent swelling and reduce the accessibility of the sites required for the absorption of the dye.[39] Some shades of dyes are altered by the resins. Light fastness and washfastness of sulphur and vat dyes are practically unaffected. With direct dyes, the washfastness is generally improved, but the lightfastness may be increased or decreased depending on the particular dye.[40]

Resin treated fabrics are less susceptible to bacterial decay, to the action of enzymes, and to rotting. This may be due to the reduced capacity for absorption of water.[41]

Two research studies of crease resistant fabrics have been completed at the University of Tennessee. Efforts to obtain these studies for reviewing purposes were unsuccessful.

Research reveals that the fabric properties of resin treated fabrics are dependent upon many variables of the impregnation, the resins and precondensates used, and the fabric construction. The crease resistance produced by the blocking of the hydroxyl group and the

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39 D. D. Gagliardi and A. C. Neussle, op. cit., p. 14.

40 Leonard Shapiro, loc. cit.

41 J. T. Marsh, op. cit., p. 424.

formation of cross linkages reduces the fabric moisture pickup and internal molecular slippage, and increases the elastic recovery of fabrics and their dimensional stability. Treated fabrics have less capacity for energy absorption and consequently lower resistance to abrasion and to tearing forces. Fabrics of resin treatment often develop unpleasant odors and are damaged by the retention of chlorine during laundering. The main loss of crease resistance occurs after the first laundering, and thereafter the crease resistance remains pretty much the same.

CHAPTER III

METHOD OF PROCEDURE

Procedure For The Wear Study

Selection of fabrics:

Since this study of crease resistant fabrics was to be a contributing part of a major study that was already in progress, the investigator for the major study had secured the fabrics to be used. Manufacturers of resin treated fabrics were contacted and given the opportunity of supplying fabrics with their crease resistant treatment for the test purposes. Of the fabrics that were offered by responding companies, those of the Erwin Cotton Mills of Cooleemee, North Carolina; Wennonah Cotton Mills Company of Lexington, North Carolina; and Dan River Mills, Incorporated of Danville, Virginia were selected for use in this portion of the research study. These three companies supplied fabrics of their manufacture in both an untreated and a resin treated form, a very desirable feature for the type of study planned. Six fabrics were received in December, 1949.

An additional fabric manufactured by Dan River was purchased in January of 1950. This fabric was selected because a later process was used in the resin finishing of the material. There was no material of the same construction in the untreated state available, so this fabric was used only to determine changes in crease resistance and strength properties after laundering and wear, and to compare these changes with those that occurred in the other resin treated fabrics.

Facts pertaining to the fabrics that were supplied by the manufacturers are presented in Table I and swatches are shown in Figure I.

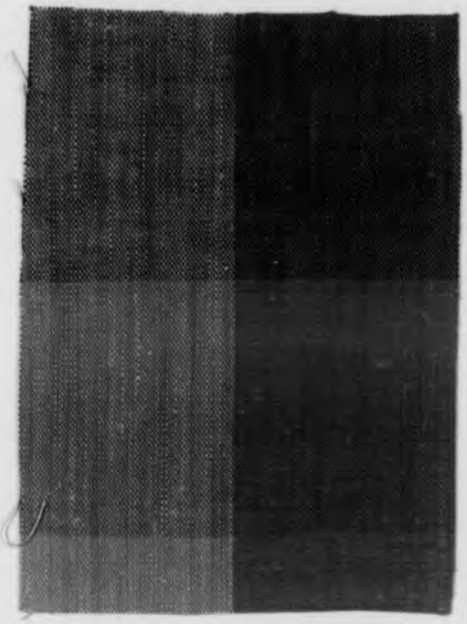
TABLE I

FABRICS USED IN THE STUDY

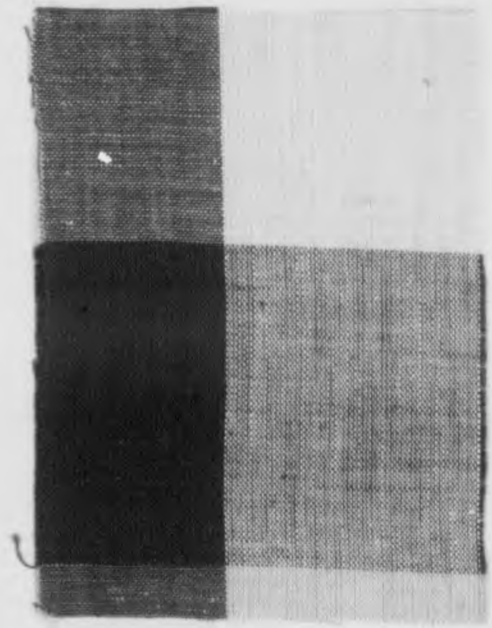
Fabric Number	Manufacturer	Fabric	Yardage	Finishes*
1	Wennonah Cotton Mills Company	Gingham	5	Preshrunk, (average shrinkage of similar fabrics tested was 3%), Bleached
2	"	"	5	Bleached, Mercerized, Superset resin finish
3	Erwin Cotton Mills	Denim	5**	Sanforized
4	"	"	5**	Superset resin finish (melamine resin)
5	Dan River Mills	Gingham	6	Sanforized
6	"	"	6	Sanforized Wrinkle-Shed resin finish
7	"	"	5	Resin finish (latest process used in January, 1950) Sanforized

* This information was furnished by the manufacturers.

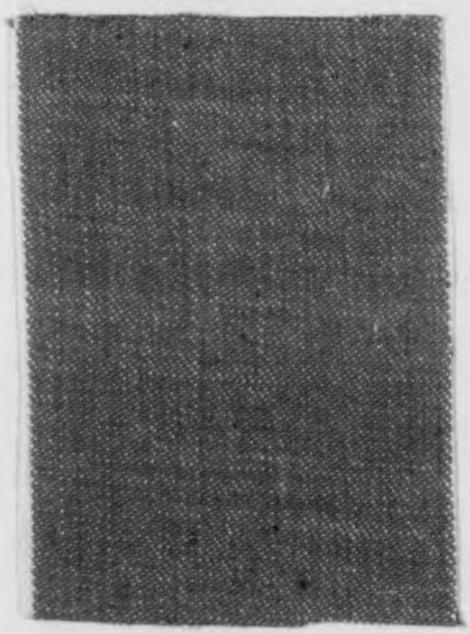
** The denims were supplied in two and one half yard lengths, which was not sufficient yardage to permit laboratory testing and the construction of a garment. Since the manufacturer furnished several denims of the same construction and finish, although in different colors, one blue denim was used for the laboratory testing, and one lavender denim was used to construct the garment for the wear study.



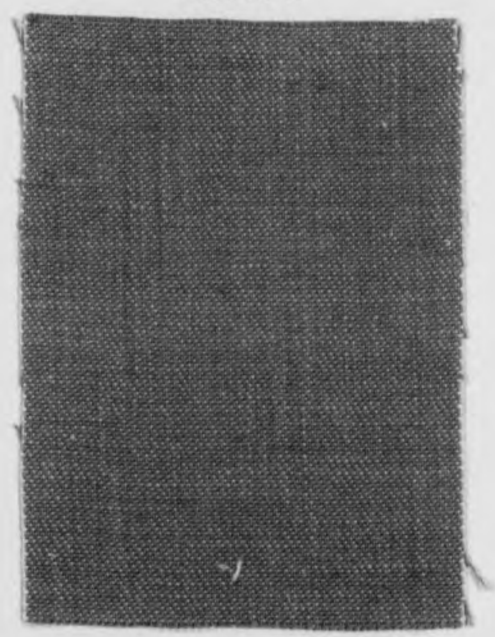
Fabric I



Fabric 2

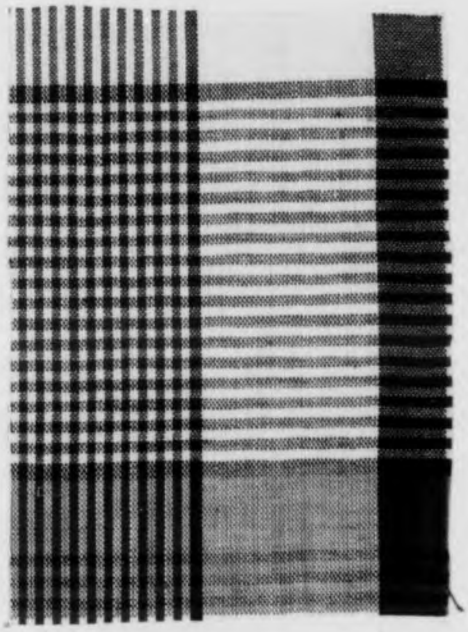


Fabric 3

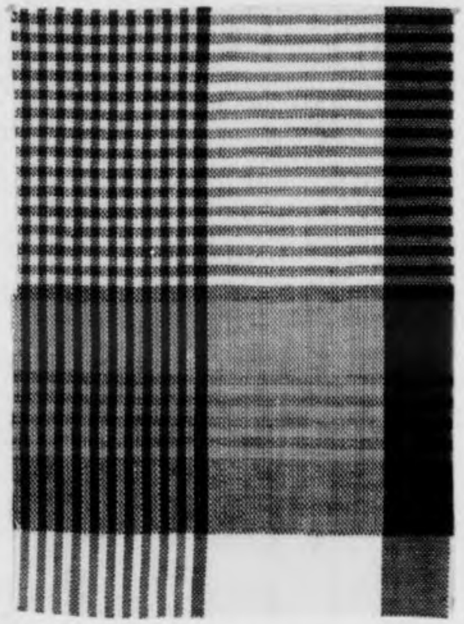


Fabric 4

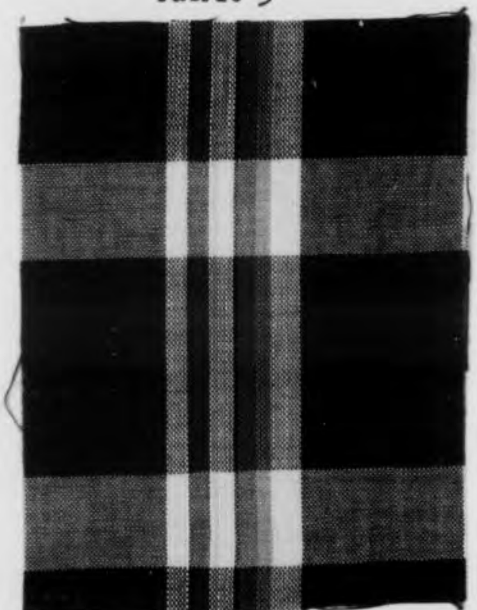
FIGURE I - Fabrics Selected for the Study



Fabric 5



Fabric 6



Fabric 7

FIGURE I (continued) - Fabric Selected for the Study

Construction of garments:

It was the original plan of the study to combine the treated and untreated fabrics in one garment. This was not possible with fabrics 1 and 2, as the manufacturer supplied the treated and untreated fabrics in different colors. Consequently, it was necessary to construct each fabric into a separate dress. This procedure was also necessary with fabric 7, as there was no untreated fabric available for the study. However, it was possible to combine fabrics 3 and 4 in one dress and fabrics 5 and 6 in one laboratory apron. In the cases where fabrics were combined, the division was placed at the center front and the center back so that equal amounts of each fabric would receive approximately equal wear.

Varied designs of garments were selected to suit the fabrics and the individuals who were to wear the garments. In addition, it was necessary to select designs having a seam at the center front and the center back to allow for the use of both treated and untreated fabrics in the same garment. In order that sufficient yardage could be reserved for the laboratory testing, designs requiring a minimum of yardage were used.

Figure 2 depicts the designs of the garments constructed from the fabrics used in the study.

Garment 1
Fabric 1

Garment 2
Fabric 2

□ - Untreated fabric
▨ - Treated fabric

FIGURE II - Designs of Garments Constructed From Test Fabrics

Garment 3
Fabrics 3,4

Garment 4
Fabrics 5, 6

- Untreated fabric
- Treated fabric

FIGURE II (continued) - Designs of Garments Constructed From Test Fabrics

Garment 5
Fabric 7

▭ - Untreated fabric
▨ - Treated fabric

FIGURE II (continued) - Designs of Garments Constructed From Test Fabrics

As the garments were constructed in the laboratory, each fabric and each garment was marked with its identifying number. Upon the completion of each dress, the individual who constructed the dress was asked to answer specific questions to indicate the fabric's adaptability to garment construction.

Planned procedure for the wear study:

The individuals participating in the wear study were given the garments and instructed in the wear, care, and record keeping necessary to furnish the type of information required for the research purposes. Each garment was to be worn and laundered as the individual wearer would usually wear and launder any cotton garment. An accurate record of the number of hours worn, the method and number of launderings, and the changes in fabric appearance, hand, or the garment fit were to be noted and recorded. After the fifth laundering, a report form was sent to each participant to record the total number of hours of wear, the total number of launderings, and the type and extent of changes that had occurred in the fabric or garment. At this time, the garments were returned to the laboratory for the evaluation of changes that had taken place.

At the end of two seasons of wear, a second similar report form was sent to each participant. The garments were then recalled to the laboratory, where a final evaluation of apparent changes was made by comparison with original swatches of the same fabrics. As this concluded the wear study, the garments were cut to form test specimens for the laboratory determination of changes in strength and anti-crease properties as described in the following section.

Procedure For The Laboratory Analysis Of Fabric Construction

Fiber content

No technical method of identification was used. One hundred per cent cotton content was indicated by visual examination, hand, and the labels applied by the manufacturer.

Weave

The fabrics tested had simple weaves that were readily identified by visual examination and verified with the pick glass.

Weight per square yard

The procedure followed was based on the test methods recommended by Skinkle[1] and the American Society for Testing Materials.[2]

Five pieces of fabric, each two inches square, were marked and cut from different areas of the fabric. No specimen was nearer the selvedge than one tenth the width of the fabric. The specimens were weighed on the analytical balance, and the weight in ounces per square yard was calculated by the following formula: $S = \frac{36 \times 36}{A} \times \frac{G}{28.35}$, where S is the ounces per square yard, A is the area of the sample in square inches, and G is the weight of the sample in grams.

The weights of the two inch squares were averaged to give the mean weight in ounces per square yard of the fabric.

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1 John Skinkle, Textile Testing, Chemical Publishing Company, Inc., Brooklyn, New York, 1949, pp. 77-80.

2 American Society for Testing Materials Committee D-13, American Society for Testing Materials Standards on Textile Materials, pp. 113. Published in Philadelphia by American Society for Testing Materials, 1950.

Thread count

The test method used was that established by the American Society for Testing Materials.[3]

With the Suter counter, the actual number of warp yarns in one linear inch was counted at five different places in the fabric. No two places counted included the same yarns, and no count was made nearer the selvedge than one tenth the width of the fabric. The number of filling yarns per linear inch was counted in the same manner. From these counts, the average number of warp and filling yarns per linear inch was calculated.

Fabric thickness

The procedure followed was that recommended by the American Society For Testing Materials and a gauge conforming to their specifications was used to measure the thickness of the fabric.[4]

The fabric was placed on the anvil of the gauge and smoothed to free from wrinkles but was not held under any tension. The presser foot was lowered upon the fabric gradually without impact and allowed to rest for ten seconds before the dial was read. Other measurements were made at five different places distributed over the surface of the fabric and exclusive of that area nearer the selvedge than one tenth the fabric width. The dial readings, which indicated the thousandths of an inch between the anvil and the presser foot, were recorded. The five measurements were averaged to give the mean thickness of the fabric.

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[3] *Ibid.*, pp. 113-114.

[4] Ibid., p. 113.

Staple length

The procedure for determining the staple length was based upon the test procedure for hand stapling of cotton fibers recommended by Skinkle[5] and modified in order that yarns could be used instead of the unwoven tufts of cotton.

A warp yarn was removed from the fabric, grasped in the hands, and untwisted. Fibers were pulled from the untwisted yarn and placed upon a slightly oiled ruler. All of the fibers were removed except one, which was smoothed and aligned with the hand. The length of the fiber upon the ruler was recorded. This operation was repeated to obtain five fiber lengths in the warp direction. The staple length was then determined by averaging the five individual fiber lengths.

The entire procedure was repeated with filling yarns to determine the staple length of fibers used in the filling direction.

Yarn number

Two systems of expressing the yarn number were employed. The count or number system was used to express the number of hanks in one pound of yarn; and the typp system was used to express the number of thousands of yards that are in one pound of yarn.

The test method as described by Skinkle[6] was used. Ten yarns thirty six inches in length were removed from the fabric in both warp and filling directions. The length of yarn was weighed on the analytical balance at room conditions, and the yarn number was calculated by the following formula: $N = \frac{I}{M} \times \frac{12,600}{H}$, where N is the

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[5] Skinkle, *op. cit.*, pp. 33 - 39.

[6] *Ibid.*, pp. 46 - 58.

count or number, I is the length of the yarn in inches, M is the weight of the yarn in milligrams, and H is the length of a standard hank, 840 yards.

The mean yarn number in the filling yarns and in the warp yarns was computed by averaging the individual yarn numbers in each case. The yarn number in the counts system was converted to the typp system by use of the yarn number conversion table prepared by the American Society for Testing Materials.[7]

Twist

The twist, or the number of spiral turns given to a yarn in order to hold the fibers together, was measured according to the test methods prepared by Skinkle.[8]

The method that was followed used a twist counter, which untwisted a determined length of yarn and measured the number of turns required to untwist the yarn. The indicator on the twist counter was set at zero, and the gauge length at five inches. The warp yarn to be tested was held at one end with enough yarn removed from the fabric to be able to secure it in one clamp of the counter. As the remainder of the yarn was removed from the fabric, it was gripped in the other clamp. The rotating arm was turned to add twist until the yarn broke. The number of turns and the direction of twist were recorded. Using another warp yarn, the same procedure was followed with the exception that the rotating arm was turned in the opposite direction to first

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7 American Society for Testing Materials, op. cit., p. 482.

8 Skinkle, op. cit., pp. 58 - 70.

untwist the yarn and then to twist it in the opposite direction until the breaking point was reached.

This procedure was repeated using ten warp and ten filling yarns for each direction of twist. The twist per inch was calculated by the formula: $TPI = \frac{N_2}{2L_2} - \frac{N_1}{2L_2}$, where TPI is the turns per inch, N_1 is the number of turns required to break the yarn by adding twist, N_2 is the number of turns required to break the yarn by first untwisting and then twisting the yarn until it breaks, L_1 is the length of the gauge used for N_1 and L_2 is the length of the gauge used for N_2. The total warp turns per inch and the total filling turns per inch were averaged to give the mean turns per inch in the warp and in the filling yarns.

Procedure For The Laboratory Determination of Fabric Serviceability

Preparation of test pieces

The swatches used for laundering and the determination of changes in dimensions, crease resistance, bursting strength, and tearing strength were prepared from the fabric that remained after the garments were cut. One entire fabric width of eighteen inches length was the desired size, with smaller pieces being necessitated in a few instances because of the scarcity of material. A ten inch square, following the warp and the filling threads, was marked with basting thread to be used for determining changes in dimensions after laundering. Five similar swatches of each fabric were prepared in order that physical changes after the first, second, fifth, tenth and twentieth launderings might be determined.

Following laundering and the determination of dimensional changes, the swatches were cut to form the test pieces required for the crease resistance, bursting strength, and tearing strength tests.

Laundering formula

The washing procedure used was based upon the tentative test method for determining dimensional changes of textile fabrics other than cotton and linen as established by the American Association of Textile Chemists and Colorists.[9] Modifications in the amount of soap used and the temperature maintained in the water bath were made to make the washing procedure more nearly approximate the laundering action fabrics would undergo in the home. The test for fabrics other than cotton and linen was selected because it was more similar to home laundering procedure than the test recommended for cotton fabrics.

A washing machine of the cylindrical, reversing wash wheel type, equipped with a pipe for injecting live steam, was used. This machine was selected because the mild, mechanical action produced by the reversing wash wheel would not be destructive to the fabrics or their finishes. The action produced would be smiliar to that of many home washers and only slightly more rigorous than a hand washing procedure.

A neutral, flaked soap of the type manufactured for home laundering was used. Sixty grams of soap was added to each load, producing a solution of approximately fifteen hundredths soap concentration.

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9 American Association of Textile Chemists and Colorists, 1951 Technical Manual and Yearbook of the A. A. T. C. C., XXVII, p. 131. New York: Howe Publishing Company, 1951.

A load weighing from a ten pound maximum to an eight pound minimum and consisting of the test pieces and additional cloth to obtain the desired weight, was washed each time.

Before beginning the washing formula, both hot and cold water were run through the machine to remove rust and other foreign matter. The test pieces and additional fabric were arranged in cotton mesh bags and placed in the wash wheel. The wash wheel was filled to the six inch level with cold water and the load was rinsed for two minutes to thoroughly wet the fabrics. This procedure was recommended by the manufacturer in order that soil which might be set with hot water or soap could be removed before the hot water or soap were added. At the conclusion of the two minute rinse, the machine was drained.

Sufficient water was added to the wash wheel to reach the six inch level. Live steam was injected to raise the temperature of the water to one hundred and twenty degrees Fahrenheit, and sixty grams of a neutral, flaked soap was added. This sudsing period was concluded after fifteen minutes, and the machine was drained.

Following the sudsing, the load was rinsed for five minutes at an eight inch water level and with the temperature at one hundred degrees Fahrenheit. The machine was drained, and a second rinse with an eight inch water level and with a temperature of one hundred degrees Fahrenheit was started. After ten minutes, the machine was drained and the washing procedure was concluded.

The test pieces were removed from the wash wheel and were placed in the extractor for an extracting period of seven minutes to reduce the fabric moisture content.

After extraction, the test pieces were pressed on a flat bed laundry press. Care was taken in handling the specimens to avoid placing any strain on the cloth. Each specimen was smoothed by hand to remove wrinkles before pressing. The press was allowed to remain on the specimen for six seconds. After pressing, the specimens were allowed to cool before measurements were made.

Dimensional change

The pressed specimens were laid out without tension on a flat surface. The distances which had been marked with basting thread were measured. Five measurements in the warp direction and five in the filling direction were recorded. The mean measurement in both warp and filling direction was determined by averaging the five measurements in each direction.

The percentage of shrinkage or stretch was calculated by the following formula: $\frac{A - B}{A} \times 100 = C$, where A is the original size of the square, B is the size of the square after laundering, and C is the percentage of stretch or shrinkage.

Physical Tests Used To Determine Changes In Fabrics After Laundering and Wear

Crease resistance

The Monsanto Wrinkle Recovery Tester was used and the test methods recommended by the manufacturer were followed.[10] Prior to

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[10] Monsanto Chemical Company, "Monsanto Wrinkle Recovery Tester," Bulletin # T-7, December 1, 1947. Published by Monsanto Chemical Company.

testing, the fabrics were conditioned at sixty five per cent relative humidity, and seventy degrees Fahrenheit for a minimum of four hours.

Five test specimens with dimensions of six tenths of an inch by one and five tenths inches were cut from the warp and filling directions, with the longer dimension representing the direction of the test. Each test specimen was placed between the metal leaves of the specimen holder with one end flush with the longer metal strip. The exposed end of the specimen was then turned back so that its edge fell on a line on the shorter metal leaf. Care was taken to avoid getting moisture from the fingers on the area to be creased.

The metal holder was held with the fabric specimen looped back in the left hand, and the left thumb nail was pressed on the edge of the specimen to hold it on the guide line. The plastic press was opened and the holder and specimen were inserted. The press was held so that the jaw with the small raised platform was outside of and parallel to the longer metal strip of the holder. The end edge of the jaw was brought into firm contact with the fabric at the left thumb nail and the press was closed. A crease was formed about one sixteenth of an inch from the end of the metal leaf.

The press holder combination was inverted on the table top with the small platform upward, and a load of one and one half pounds was applied to the platform for five minutes. The press was uncovered, the holder was removed, and mounted in the tester. The back edge of the holder was placed against the back edge of the shelf of the tester, and the holder was slowly pushed into position.

The dangling leg of the specimen was aligned with the vertical guide lines on the back panel and was readjusted periodically as the specimen recovered. After a five minute recovery period, the degree scale reading was recorded.

The five readings of test specimens in the warp direction were averaged to find the mean angle of recovery. The same procedure was followed for the filling yarns. The mean angle of recovery of both warp and filling test specimens were used as an indication of the anti-crease values of the fabrics.

Bursting strength

The test method as outlined by the American Society for Testing Materials was followed.[11] Although the test is set up for knit goods, it was felt that the changes in the strength of woven fabrics could likewise be indicated. The machine used was of the approved type of diaphragm bursting tester.

The test specimens were clamped in position over the diaphragm, and the gear was moved to throw the machine in motion. When rupture of the fabric occurred, the gear was moved to stop the machine, and the dial reading was recorded. After five dry specimens had been tested, five wet specimens were subjected to the same procedure. Individual results were averaged to determine the average dry bursting strength and the average wet bursting strength.

Tearing strength

The tongue method for determining tearing strength as recommended by the American Society for Testing Materials[12] was followed.

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[11] American Society for Testing Materials, op. cit., p. 119.

[12] American Society for Testing Materials, op. cit., pp. 114 - 115.

Tests were performed under standard conditions. The fabric was allowed to reach moisture equilibrium with a standard stmosphere, which had a relative humidity of sixty five per cent at seventy degrees Fahrenheit.

Two sets of five specimens were prepared, one set for warp tearing strength having the longer dimension in the direction of the warp yarns, and one set for filling tearing strength having the longer dimension in the direction of the filling yarns. The specimens measured three inches in width and eight inches in length. A longitudinal cut of three inches was made in the specimen by starting in the center of one of the short edges.

A machine of the pendulum type was used and the pawls on the pendulum were disengaged from the ratchet. At the start of the test, the distance between the clamps was three inches. The face of one jaw of each clamp measured one inch by one inch and that of the other clamp measured one inch by two inches, with the longer dimension perpendicular to the application of the load.

The specimens were placed in the machine with one of the tongues in each clamp. The machine was started and the load required to tear the fabric was noted on the recording device. The average of the five individual tests in the warp direction reported the warp tearing strength, and the average of the five individual tests in the filling direction reported the filling tearing strength.

The same procedure was repeated, using wet fabrics to determine the wet tearing strength in the warp and filling directions of the fabrics.

CHAPTER IV

PRESENTATION OF DATA

Data of the wear tests and of the laboratory tests are presented in this chapter. The results of the wear tests and of the laboratory tests are compared to determine the similarity of the results obtained by the two different test methods.

Laboratory Analysis of Fabric Construction

The seven fabrics were of one hundred per cent cotton content; and all fabrics were ginghams of plain weave construction with the exception of fabrics 3 and 4, which were denims of twill weave construction. The weight of the five ginghams was similar, varying only from 3.1 to 3.6 ounces per square yard. Less similarity was found to exist in the thickness of the fabrics. Fabrics 3 and 4, the denims, had the greatest thickness with average measurements varying from .043 to .045 inches. The thickness of fabrics 1 and 2 ranged from .033 to .034 inches and that of fabrics 5, 6, and 7 from .014 to .019 inches. There were also considerable differences in the thread count of the fabrics. The warp thread count was 80 in fabrics 1 and 2, and varied from 67 to 66 in fabrics 3 and 4, and from 80 to 82 in fabrics 5, 6, and 7. The filling thread count varied from 55 to 57 in fabrics 1 and 2, from 40 to 46 in fabrics 3 and 4, and from 67 to 70 in fabrics 5, 6, and 7.

From the measurement of individual factors contributing to the total fabric construction, there was no indication of any difference in the construction of untreated and resin treated fabrics. There were minor differences which seemed to be due to the variations in the construction of the individual fabrics rather than being caused by the presence or absence of resin treatments.

Average measurements of the fabric properties described in the preceding paragraph are recorded in Table II. In addition, average measurements are included for the staple length of the fibers in the warp and filling yarns, the typp yarn number of the warp and filling threads, and the twists per inch of the warp and filling threads.

TABLE II

Laboratory Analysis of Fabric Construction

Fabric Number	Fabric	Fiber Content	Weave	Weight per square yard	Thread Count Warp	Thread Count Filling	Thickness	Staple Length Warp	Staple Length Filling	Yarn Number (TYPP) Warp	Yarn Number (TYPP) Filling	Twist per Inch Warp	Twist per Inch Filling	Treated for Crease Resistance
1	Gingham	Cotton	Plain	3.6	80	57	.033	1.16	1.16	26.4	27.5	24.0Z	20.6Z	No
2	Gingham	Cotton	Plain	3.1	80	55	.034	1.13	1.19	26.0	26.0	24.2Z	23.0Z	Yes
3	Denim	Cotton	Twill	6.5	67	40	.043	1.12	1.15	10.4	9.5	16.4Z	12.9Z	No
4	Denim	Cotton	Twill	8.0	66	46	.045	1.16	1.15	9.1	9.9	17.2Z	13.3Z	Yes
5	Gingham	Cotton	Plain	3.1	81	68	.018	1.06	1.01	29.8	31.4	27.0S	26.7S	No
6	Gingham	Cotton	Plain	3.2	80	70	.014	1.01	1.02	29.8	30.4	25.4S	26.4S	Yes
7	Gingham	Cotton	Plain	3.2	82	67	.019	1.05	1.02	29.7	29.4	25.0S	29.2S	Yes

Results of the Wear Study

Adaptability of Fabrics to Garment Construction

From the information supplied by persons who made the garments, the adaptability of the fabrics to garment construction was determined.

The persons who made the garments thought that all of the fabrics had satisfactory weight for the type of garment constructed. In describing the fabric hand, various descriptions were given. Fabrics 1 and 2 were described as soft, fine, and smooth; fabric 3 as coarse and stiff, but not as coarse and stiff as fabric 4; fabric 5 as soft and smooth; and fabrics 6 and 7 as fine and stiff. The description of the hand of fabrics 1 and 2 was the same. This lack of apparent difference in the two fabrics was also reflected by the inability of the person constructing the garment to detect any evidence of a crease resistant finish in fabric 2. In all other cases, it was possible to distinguish between the treated and untreated fabrics.

No unusual problems were encountered during construction of the garments although minor problems appeared with specific construction details. One such problem was the elimination of fullness. The garment made from fabrics 3 and 4 had little fullness to be eliminated, but that amount present could not be handled. Fullness was eliminated satisfactorily in other garments, or no judgment could be made because of the absence of fullness from the design. The response of the fabrics to pleating was satisfactory in all cases where pleats were used. Despite some problems, the fabrics were considered easy to handle. With fabrics 3 and 4, the following justification was added, "Easy to handle in the type of garment used."

As a whole, little difficulty was experienced in the fabric handling during construction. One factor that was probably influential in this result was the selection of designs that did not provide the opportunity for the fabrics to exhibit their full potentialities for offering problems. It is doubtful that fabrics 3 and 4 would have responded satisfactorily to pleating or to any elimination of fullness, as the fabrics were very stiff and unyielding. The harshness of hand present in treated fabrics 4, 6, and 7, and absent from fabric 2, indicates that fabric 2 either had little crease resistance or that the crease resistance present did not produce the same changes in hand as were produced in the other resin treated fabrics. This absence of harsh hand made fabric 2 one of the easiest to handle during construction.

The adaptability to construction varied from fabric to fabric; so there must be some variable in the process of resin application that influences fabric handling, or it is possible that the variation could be caused by differences in fabric construction. The ease of handling the fabric during construction is influenced by the type of design used.

Tabulated information compiled from the report forms on garment construction is given in Table III.

TABLE III

Adaptability of Fabrics to Garment Construction

Garment	Fabric	Suitability of fabric weight to the garment constructed	Description of hand	Evidence of crease resistant finish	Unusual problem encountered during construction	Response of fabric to the elimination of fullness	Response of fabric to pleating	Ease of handling fabric	Comments
1	1	Satisfactory	Soft, fine, and smooth	None	None	Very well, but little elimination was necessary	Very well	Easy to handle	-----
2	2	Satisfactory	Soft, fine, and smooth	None	None	Very well	Very well	Easy to handle	-----
3	3	Satisfactory	Not as coarse and stiff as treated half	None on one side of garment	None	Little to be eliminated, but the amount present could not be eliminated	No pleats	Easy to handle in the type of garment constructed	-----
	4	Satisfactory	Coarse and stiff	Yes, on one side of garment	None	Little to be eliminated, but the amount present could not be eliminated	No pleats	Easy to handle in the type of garment constructed	-----
4	5	Satisfactory	Soft, smooth	None	None	None to be eliminated	Very well	Easy to handle	-----
	6	Satisfactory	Fine, stiff	Yes	None	No elimination of fullness was necessary	Very well	Easy to handle	Irons very smoothly
5	7	Satisfactory	Fine, stiff	Yes	None	Fairly well	Very well	Easy to handle	Ironed very easily

Wearer's First Report of Garment Serviceability

After one season of wear and laundering, the wearers reported on the serviceability being received from their garments. The data compiled from these reports were examined to determine the quality of service being received from the resin treated fabric as compared with the quality of service being received from the untreated fabrics.

Since no definite method of laundering was prescribed, several different methods were used. Most of the garments were washed by hand. In addition, garment 2 was washed in an agitator type washer with wringer; and garment 3 was washed in an automatic washing machine. With all the garments, moderately hot water was used and either a mild, flaked soap or a powdered detergent was employed as the cleansing agent. All fabrics were easy to iron. With garment 4, the treated half was easier to iron than was the untreated half. Garment 5 was very easy to iron.

There were no changes in fit after laundering, but there were changes in hand. Fabric 2 became slightly softer, and fabric 7 in garment 5 lost some stiffness. Garment 1, which contained untreated fabric, was very limp after laundering and wrinkled very easily. Garment 2, which contained the treated fabric of the same construction as fabric 1, had only a very slight softening of hand. Few wrinkles appeared in garment 2 and those wrinkles that occurred disappeared after hanging. There was little wrinkling or creasing on either side of garment 3. The absence of wrinkles was attributed to the fact that the fabrics were of heavy weight and firm body. In garment 4, the untreated half wrinkled much more than did the treated half, which was resistant to wrinkling. A few wrinkles appeared in garment 5 but disappeared after the garment was allowed to hang.

After laundering and wear, some changes appeared in the fabrics. The major change was in hand. Most of the treated fabrics became softer and lost some of their original stiffness. The harsh hand of treated fabrics is thought to be due to the deposit of surplus resin in and between the fibers of the fabrics; so the change in hand was probably due to the removal of the surplus resin during laundering. There were no changes in fit, so it could be concluded that the fabrics were dimensionally stable insofar as the wearers were able to judge. The treated fabrics showed less tendency to wrinkle and an increased tendency to lose wrinkles upon hanging than did untreated fabrics of the same construction. All results showed that after one season of wear the treated fabrics were giving better serviceability than were untreated fabrics of the same construction.

All data of the wearers' first report of garment serviceability are presented in Table IV.

TABLE IV

Wearers' First Report of Garment Serviceability

Garment	Fabric	Garment fit prior to laundering	Hand of fabric prior to laundering	Method of laundering	Laundering of garments: Approximate temperature of water	Laundering of garments: Soap or detergent used	Ease of ironing fabric	Changes in fit after laundering	Changes in hand after laundering	Resistance of fabric to wrinkling	Comments
1	1	Very nicely	Soft	Hand washing	Moderately hot	Ivory Soap	Easy to iron	None	None	Wrinkles easily	Garment appears limp after first laundering. Fabric is very cool
2	2	Perfect	Smooth	Hand washing and machine washing with regular washer and wringer	Moderately hot	Ivory Snow, Tide	Easy to iron	None	Very little, perhaps slightly softer	Little wrinkling takes place; many wrinkles disappear after hanging	----------
3	3 and 4	Very well	Untreated half was stiff, but not as stiff as treated half	Machine washing in Whirlpool Washing Machine	Moderately hot	Tide	Easy to iron	None	None	Little creasing and wrinkling occur	There was little wrinkling on either side as the fabric was of a heavy weight and firm body
4	5 and 6	Excellent	Treated half is slightly stiffer and is slightly scratchy	Hand washing	Moderately hot	Ivory Snow	Treated half irons much more easily than untreated	None	None	Treated half has little wrinkling. Untreated half wrinkles much more easily	----------
5	7	Very well	Stiff, smooth	Hand washing	Moderately hot	Tide	Very easy to iron	None	Slightly less stiffness	Little wrinkling and all wrinkles disappear after hanging	----------

Laboratory Evaluation of Apparent Changes in Fabrics After the First Season of Wear

The laboratory evaluation of apparent changes in the fabrics after one season of wear verified the changes in hand reported by the wearers. Prior to this evaluation, the garments had been laundered an average of five times, the number of launderings varying from two to seven times.

All fabrics showed some softening of hand. The changes were more marked in the untreated fabrics than in the treated fabrics. The loss of stiffness in the untreated fabrics was probably due to the removal of sizing and other water soluble finishes during the laundering process. There were no color changes or indications of wear except in fabric 3 of garment 3. In this fabric, a roughening of fibers on the fabric surface caused a slight color change that was considered Class II.[1] The change in this fabric was probably a result of the abrasive action encountered during wear.

At this time, it was evident that the treated fabrics were still more able to resist wrinkling than were the untreated fabrics.

All changes that occurred in the fabrics are reported in Table V.

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1 Borton, Helen and Butz, Mina, et al "Colorfastness of Women's and Children's Wearing Apparel Fabrics," Journal of Home Economics, XXXIV: 539, October, 1942.

Classification of color changes:

Class I - No change.
Class II - Little change from the original.
Class III - Definite change from the original but the fabric could still be used.
Class IV - Very evident color changes. Could not be used again.

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TABLE V

Laboratory Evaluation of Apparent Changes After The First Season of Wear

Garment	Fabric	Times Laundered	Apparent Differences in hand	Color Changes: Apparent Changes	Color Changes: Explanation of Changes	Color Changes: Classification of Change	Indication of wear	Wear Changes: Description of wear	Wear Changes: Location of wear	Wear Changes: Cause of wear
1	1	5	Has less body and is softer than original fabric	None	----------	Class I	None	----------	--------	----------
2	2	7	Softer than original fabric	None	----------	Class I	None	----------	--------	----------
3	3 and 4	2	Untreated fabric was softer after the first laundering. Treated fabric was slightly softer, but stiffer than the untreated	None in treated. Slight color change in the untreated fabric due to the roughening of the fibers		Class I Class II	Slight roughening of fibers in untreated fabric	----------	Entire half of garment	Abrasive action encountered during wear
4	5 and 6	7	Both halves are softer and have less body than original fabric	None	----------	Class I	None	----------	--------	----------
5	7	3	Has slightly less body than original fabric	None	----------	Class I	None	----------	--------	----------

Wearers' Final Report of Garment Serviceability

The reports of garment serviceability after the second season of wear revealed that additional changes had occurred in the fabrics. At this point, which was the conclusion of the wear study, the garments had been laundered an average of 7 times, the number of launderings varying from 6 to 9 times. The methods of laundering were the same with the exception of the method used for garment 3, which was that of a commercial washing machine of the type producing a mild laundering action.

There were still no changes in fit, indicating that the fabrics were retaining their original shape and dimensions. There were additional changes in hand that were more evident in the treated fabrics than in the untreated fabrics. The treated fabrics became softer and as one wearer stated, "required more starching." This wearer of garment 4 also thought that her garment had reached the stage that the same amount of wrinkling occurred in both fabrics. Garment 3 showed the roughening of the fibers to such an extent that the wearer detected the change. The wearer of garment 3 thought that the treated part of her garment showed a slight loss of anti-wrinkling properties. She could tell that the treated half of her garment was resisting wrinkling to a greater degree than was the untreated half, although her entire garment had given good service in resisting wrinkling. In garments 1 and 2, the wearers did not notice any changes in hand or wrinkle resistance.

The fabrics retained their shape very well, and only in fabric 3 was there any indication of wear or color change. In fabric 6 it was apparent that most of the anti-crease properties were lost after two seasons of wear and laundering. There seemed to be a considerable amount of the crease resistance retained in fabric 4, for the wearer could still detect differences in the wrinkling tendencies of this fabric and the untreated portion. Fabric 2 either lost very little crease resistance or it had very little crease resistance in its original state, for only very slight changes were noted in its' wrinkling tendency throughout the study.

There seemed to be no relation between the changes that occurred in the resin treated fabrics and the conditions of wear and laundering. The amount of crease resistance retained after wear and laundering must be influenced by the particular method of resin impregnation employed to finish the fabric or by the varying ability of fabrics of different construction to absorb and retain the resin.

All data of these reports are included in Table VI.

TABLE VI

Wearers' Final Report of Garment Serviceability

Garment	Fabric	Laundering: Times	Laundering: Method	Laundering: Approximate temperature	Laundering: Soap or detergent used	Changes in fit	Changes in hand	Indications of wear	Changes in wrinkle resistance
1	1	9	Home washer (Bendix)	Medium	Tide	None	None	None	None
2	2	8	Home washer and wringer	Hot	Tide Felso	None	None	None	None
3	3 and 4	6	Cascade Commercial Washer	120°	Ivory	None	Less body in each fabric, but more body in the treated fabric	There has been a roughening of the surface of the untreated fabric	None - The garment has been unusually satisfactory in resisting wrinkling. Both treated and untreated fabrics resist creases, but the treated fabric has been more resistant than the untreated
4	5 and 6	8	Hand washing	Moderately hot	Ivory Snow	None	Fabric is softer, requires more starching	Both sides now wrinkle about the same amount	Both sides now wrinkle about the same amount
5	7	6	Hand washing	Moderately hot	Tide	None	None	None	None

Final Laboratory Evaluation of Apparent Changes in Fabrics

At the time of the final laboratory evaluation, the garments had been laundered an average of 7 times, the number of launderings varying from 6 to 9 times. All fabrics had undergone changes in hand, losing some stiffness and body. This loss was definite in fabric 2, even though it was not detected by the wearer. The changes in hand were more marked in the treated fabrics than in the untreated fabrics. There was still no evidence of wear or color change except in fabric 3. The color loss in this fabric was more decided than at the first evaluation and was considered Class III.

These results verified the final reports of the wearers, except for the discrimination in garment 2. All fabrics lost stiffness. In the untreated fabrics, the loss was very definite and was probably due to the removal of sizing during laundering. In the treated fabrics, there was a change in hand most likely caused by the loss of some of the resin finish. This loss of resin finish also caused the fabrics to have an increased tendency to wrinkle. The extent of the loss of crease resistance and the changes in hand varied with the fabrics. Since the methods of laundering and the conditions of wear were similar, the difference in the loss of crease resistance must be due to variations in the process of resin impregnation used by the manufacturers, or to variations resulting from the different fabric constructions.

The results of the final laboratory evaluation of apparent changes in fabrics are presented in Table VII.

TABLE VII

Final Laboratory Evaluation of Apparent Change in Fabrics

Garment	Fabric	Times Laundered	Apparent Differences in hand	Color Changes: Apparent Changes	Color Changes: Explanation of Changes	Color Changes: Classification of Change	Wear Changes: Indications of wear	Wear Changes: Description of wear	Wear Changes: Location of wear	Wear Changes: Cause of Wear
1	1	9	Is softer and has less body than original fabric. No evidence of any finish. Has lost original sizing	None	----------	Class I	None	----------	--------	----------
2	2	8	Much softer, less scratchy, much less body	None	----------	Class I	None	----------	--------	----------
3	3 and 4	6	Untreated has a roughening of surface which has some effect on color. Both fabrics are softer and have less body	Some in untreated	Due to roughening of fibers	Class III Class II	Roughening in untreated part	Roughening of surface	Entire surface of one half of garment	Abrasive action encountered during wear
4	5 and 6	8	Untreated fabric is softer than treated and has less body. Treated fabric has lost some stiffness and crispness	None	----------	Class I	None	----------	--------	----------

TABLE VII (continued)

Final Laboratory Evaluation of Apparent Change in Fabrics

Garment	Fabric	Times Laundered	Apparent Differences in hand	Color Changes: Apparent Changes	Color Changes: Explanation of Changes	Color Changes: Classification of Change	Wear Changes: Indications of wear	Wear Changes: Description or wear	Wear Changes: Location of wear	Wear Changes: Cause of Wear
5	7	6	Slightly less body, doesn't have as scratchy a surface as the original fabric	None	----------	Class I	None	----------	--------	----------

Results of the Laboratory Tests

Dimensional Changes Occurring after Laundering

Of the fabrics tested, 3, 5, 6, and 7 were sanforized and guaranteed to shrink no more than 1.0 per cent. Fabric 1 had been pre-shrunk to some extent; but the manufacturer stated that of similar fabrics tested, the shrinkage was 3.0 per cent. This shrinkage is high and would produce undesirable changes in garment fit. The maximum amount of shrinkage or stretch that can take place without causing noticeable change in fabric dimensions is 2.0 per cent. A 1.0 per cent shrinkage is much more desirable, and shrinkage under 1.0 per cent is preferable as no noticeable changes in fabric dimensions would be produced.

After the first laundering, there were many changes in dimensions. Fabric 1 shrank 3.6 per cent in the warp direction and stretched 0.5 per cent in the filling direction, while fabric 2 shrank 1.6 per cent in the warp, and 1.3 per cent in the filling yarns. Fabric 3 showed no change in the warp, but shrank 0.2 per cent in the filling. Fabric 4, the treated specimen, stretched 1.2 per cent in the warp and shrank 2.9 per cent in the filling yarns. Fabric 5 had more definite changes than did the treated fabric 6. Fabric 5 shrank 3.0 per cent in the warp and 3.4 per cent in the filling, and fabric 6 stretched 0.4 per cent in the warp and shrank 1.4 per cent in the filling. Fabric 7 shrank 0.8 per cent in both the warp and filling directions. In fabrics 1, 2, 3, and 4, the treated fabrics had less change in dimensions than did the untreated fabrics. In fabrics 3 and 4, the reverse was true. There were greater dimensional changes in the treated fabrics than in the untreated fabrics.

After the second laundering, most of the dimensions were in closer approximation of the original dimensions than they were after the first laundering. Fabric 1 had a warp shrinkage of 1.5 per cent and filling stretch of 0.1 per cent after two launderings in contrast to a warp shrinkage of 3.6 per cent and filling stretch of 0.5 per cent after one laundering. Fabric 2 shrank 1.8 per cent in the warp and 0.2 per cent in the filling after two launderings. This was an increase in warp shrinkage of 0.2 per cent, but there was a decrease in the filling shrinkage of 1.1 per cent. Fabric 3 had greater changes in both directions. There was a stretch of 0.3 per cent in the warp and a shrinkage of 0.6 per cent in the filling. Similar trends were established in the other fabrics. There was either a decrease in the percentage of change or both dimensions, or the percentage of change in one dimension increased while the percentage of change in the other dimension decreased.

After the fifth and tenth launderings, there was a gradual increase in dimensional changes. After the twentieth laundering, the percentage of change was similar to that occurring after the first laundering. In most cases, there had been a progressive increase in shrinkage or stretch from the time of the second laundering. After twenty launderings, fabric 1 had shrunk 4.0 per cent in the warp and stretched 1.0 per cent in the filling in contrast to a shrinkage of 2.5 per cent in the warp and 1.3 per cent in the filling of the untreated fabric 2. Fabric 3 stretched 0.8 per cent in the warp and shrank 1.4 per cent in the filling, while the treated fabric 4 stretched 0.4 per cent in the warp and shrank 0.8 per cent in the filling. Fabric 6 also had less dimensional change than did fabric 5. Fabric 6 stretched 0.1 per cent in the warp and shrank 2.0 per cent in the filling; but fabric 5 shrank 3.4 per cent in the warp and 3.6 per cent in the filling.

The greatest single change in fabric dimensions occurred after the first laundering. Some stretch is to be expected upon the first laundering of sanforized fabrics as they tend to relax after the induced shrinkage of sanforization. After the fabrics were laundered the second time, the dimensions were much nearer those of the original fabrics. From the fifth through the twentieth launderings, there was a gradual increase in the percentage of dimensional change. After the twentieth laundering, the dimensions were in close approximation of the dimensions that were present after the first laundering. At this point, all of the treated fabrics had smaller percentages of dimensional change than did the untreated fabrics. Only in the warp of fabric 2 did any measurement of change in the treated fabrics exceed 2.0 per cent. In the untreated fabrics, the warp of fabric 1 shrank 4.0 per cent, the warp of fabric 5 shrank 3.4 per cent and the filling of fabric 5 shrank 3.6 per cent. All three shrinkages were of sufficient amount to affect the garment serviceability. Several of the sanforized fabrics had more shrinkage than the 1.0 per cent maximum allowance. The most drastic deviation from the 1.0 per cent allowance was in fabric 5, which shrank 3.4 per cent in the warp and 3.6 per cent in the filling.

Since fabrics of different construction were used, it could be expected that the amount of shrinkage which would take place would vary with the different fabrics. However, there were variations in fabrics of the same construction and preshrinkage treatment; therefore, the variation in dimensional stability must be affected by the presence of resin finishes. All fabrics of resin treatment were more stable dimensionally, so the resin impregnation must improve the dimensional stability of such treated fabric.

Average measurements of warp and filling dimensions of the test fabrics after the first, second, fifth, tenth, and twentieth launderings are recorded in Table VIII. Graphs depicting the difference in the dimensional stability of treated and untreated fabrics of the same construction are presented in Figure 3, page 61.

TABLE VIII

Percentage of Dimensional Change Occurring After Laundering And Wear

Number of Launderings	Fabrics: 1 Warp	1 Filling	2 Warp	2 Filling	3 Warp	3 Filling	4 Warp	4 Filling	5 Warp	5 Filling	6 Warp	6 Filling	7 Warp	7 Filling
1	-3.6*	+.5*	-1.6	-1.3	0.0	-0.2	+1.2	-2.9	-3.0	-3.4	+0.4	-1.4	-0.8	-0.8
2	-1.5	+0.1	-1.8	-0.2	+0.3	-0.6	0.0	-0.7	-0.9	-4.1	+0.2	-1.3	0.0	-1.6
5	-1.8	-0.2	-1.8	-0.4	+0.7	-1.1	+0.4	-0.7	-2.0	-3.7	+0.3	-1.3	0.0	-1.6
10	-3.2	+0.5	-2.0	-0.4	+0.8	-1.1	+0.3	-0.8	-2.3	-4.0	+0.4	-2.0	0.0	-1.5
20	-4.0	+1.0	-2.5	-1.3	+0.8	-1.4	+0.4	-0.8	-3.4	-3.6	+0.1	-2.0	+0.1	-1.6

* Stretch is indicated by +; shrinkage is indicated by -.

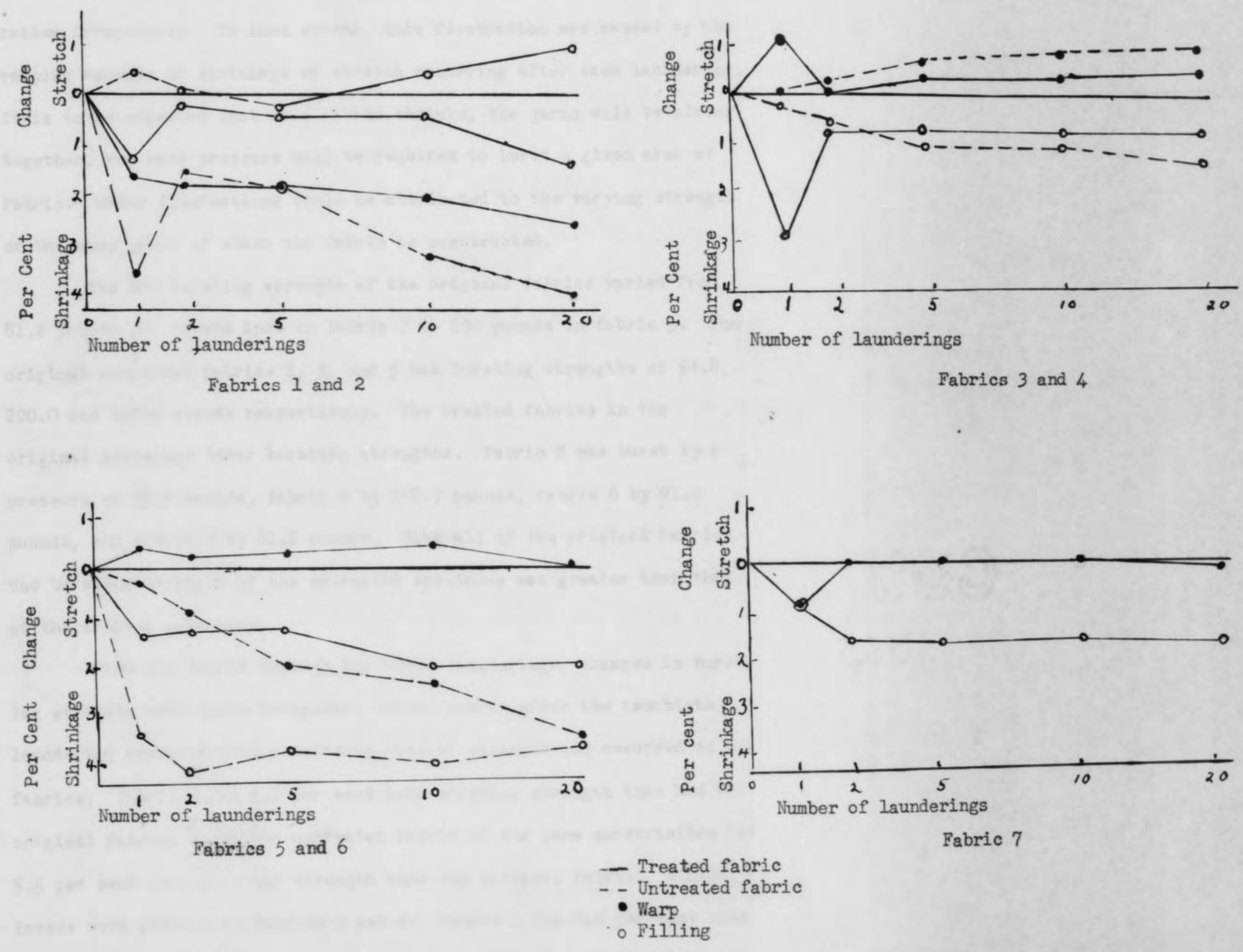


Figure 3 - Percentage of Dimensional Change Occurring After Laundering

Changes in Bursting Strength Occurring After Laundering

In some cases, the bursting strength of the fabrics fluctuated rather irregularly. To some extent, this fluctuation was caused by the varying amounts of shrinkage or stretch occurring after each laundering. It is to be expected that as a fabric shrinks, the yarns will be closer together, and more pressure will be required to burst a given area of fabric. Other fluctuations could be attributed to the varying strength of the many yarns of which the fabric is constructed.

The dry bursting strength of the original fabrics varied from 81.2 pounds per square inch in fabric 7 to 200 pounds in fabric 3. The original untreated fabrics 1, 3, and 5 had bursting strengths of 94.8, 200.0 and 105.6 pounds respectively. The treated fabrics in the original state had lower bursting strengths. Fabric 2 was burst by a pressure of 83.3 pounds, fabric 4 by 158.7 pounds, fabric 6 by 91.0 pounds, and fabric 7 by 81.2 pounds. With all of the original fabrics, the bursting strength of the untreated specimens was greater than that of the treated specimens.

From the second through the tenth launderings, changes in bursting strength were quite irregular. Measurements after the twentieth laundering revealed that a definite loss of strength had occurred in all fabrics. Fabric 1 had 4.1 per cent less bursting strength than had the original fabric, while the untreated fabric of the same construction had 5.5 per cent less bursting strength than the original fabric. Similar losses were present in fabrics 3 and 4. Fabric 3 had 8.4 per cent less strength; and fabric 4 had 9.1 per cent less strength. With fabrics 5 and 6, the treated fabric had a slightly greater loss in strength than the untreated fabric. Fabric 5 lost 10.6 per cent; and fabric 6 lost

9.9 per cent in strength. Fabric 7 lost 6.4 per cent of its strength after 20 launderings.

With the wet bursting strength tests, the same trends were evident. It was determined that the bursting strength of the original fabrics was greater in all of the untreated fabrics than in the treated fabrics except in fabrics 3 and 4 where it was impossible to determine exact changes because the bursting strength of the fabrics exceeded measurements that the tester would record. In these cases, the maximum pressure recorded by the machine, 200.0 pounds, was used as the basis for determining the percentage of change occurring in the fabrics. As was to be expected, the wet bursting strengths were greater than the dry bursting strengths. Measurements of the original fabrics varied from over 200.0 pounds to 112.8 pounds in the untreated fabrics and from 200.0 pounds to 92.6 pounds in the treated fabrics. After twenty launderings, most of the treated fabrics had lost a higher percentage of bursting strength than had the untreated fabrics. Fabric 1 had 1.6 per cent less strength, while the treated fabric 2 had lost 8.0 per cent of its strength. It was impossible to ascertain the exact loss in fabrics 3 and 4, as all measurements of fabric 3 and some of fabric 4 exceeded 200.0 pounds. The loss of strength in fabric 4 was approximately 8.8 per cent. Fabrics 5, 6, and 7 lost 10.4 per cent, 8.8 per cent, and 15.6 per cent respectively.

With both wet and dry specimens, the bursting strength of the original fabrics was less in the treated fabrics than in the untreated fabrics of the same construction. After 20 launderings, a slightly greater percentage of loss occurred in most of the treated fabrics than occurred in the untreated fabrics. Since the treated and untreated fabrics were of the same construction, the smaller bursting strength of the treated fabrics must be attributed to the presence of the resin finish. This finish caused the treated fabrics to have less strength throughout the study. However, the percentage of loss of strength of the treated fabrics was only slightly greater than that lost in the untreated fabrics. The loss of strength that occurred in the resin treated fabrics was not of sufficient amount to cause appreciable impairment of the wearing qualities of the fabrics.

Measurements of the bursting strength of the fabrics are recorded in Table IX and Table X. Graphical comparisons of the changes occurring in treated and untreated fabrics of the same construction are presented in Figure 4, pages 67 and 68.

TABLE IX

Changes In Dry Bursting Strength Occurring After Laundering And Wear
(in pounds per square inch)

Fabric	1	2	3	4	5	6	7
Original fabric	94.8	83.3	200.0	158.7	105.6	91.0	81.2
After 1 laundering	86.8	84.4	193.6	170.4	94.0	87.5	84.4
After 2 launderings	97.0	74.4	187.2	142.4	94.8	77.5	80.0
After 5 launderings	96.0	76.4	187.2	151.2	104.0	79.8	71.2
After 10 launderings	88.0	78.0	182.0	154.4	102.0	80.0	80.0
After 20 launderings	91.0	78.8	183.2	144.4	94.4	82.0	76.0
Dress specimen	92.0	80.0	190.4	147.0	97.3	83.8	77.0

TABLE X

Changes In Wet Bursting Strength Occurring After Laundering and Wear
(in pounds per square inch)

Fabric	1	2	3	4	5	6	7
Original fabric	112.8	92.6	200.0+	200.0+	127.2	103.6	96.0
After 1 laundering	112.4	96.8	200.0+	200.0+	130.4	99.6	88.4
After 2 launderings	117.6	85.2	200.0+	172.8	124.4	100.0	90.8
After 5 launderings	118.4	88.8	200.0+	174.0	128.4	97.6	89.6
After 10 launderings	119.6	84.0	200.0+	185.6	119.6	96.0	86.0
After 20 launderings	111.0	85.2	200.0+	182.4	114.0	94.5	81.0
Dress specimens	108.0	88.0	200.0+	185.0	118.0	95.2	84.4

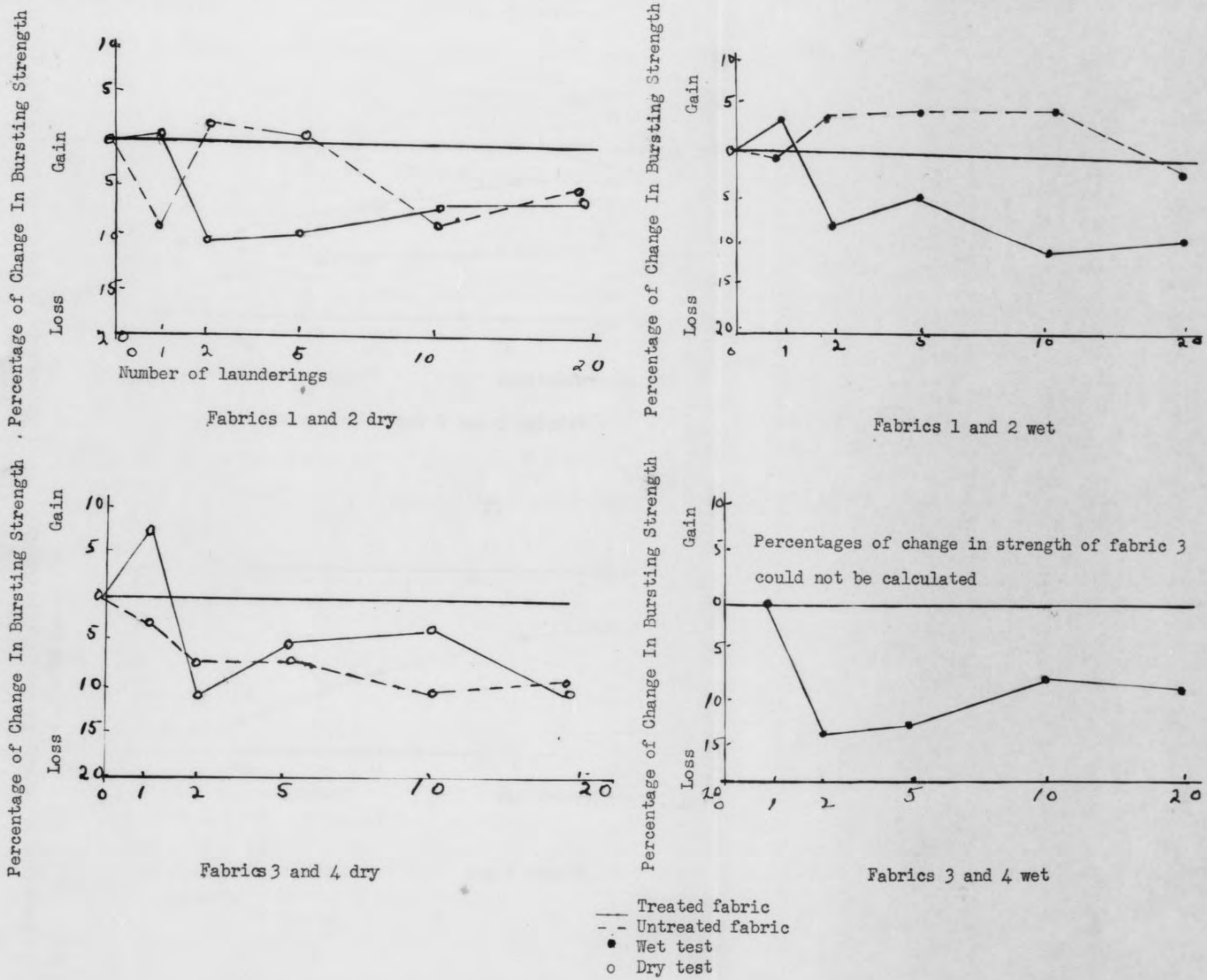
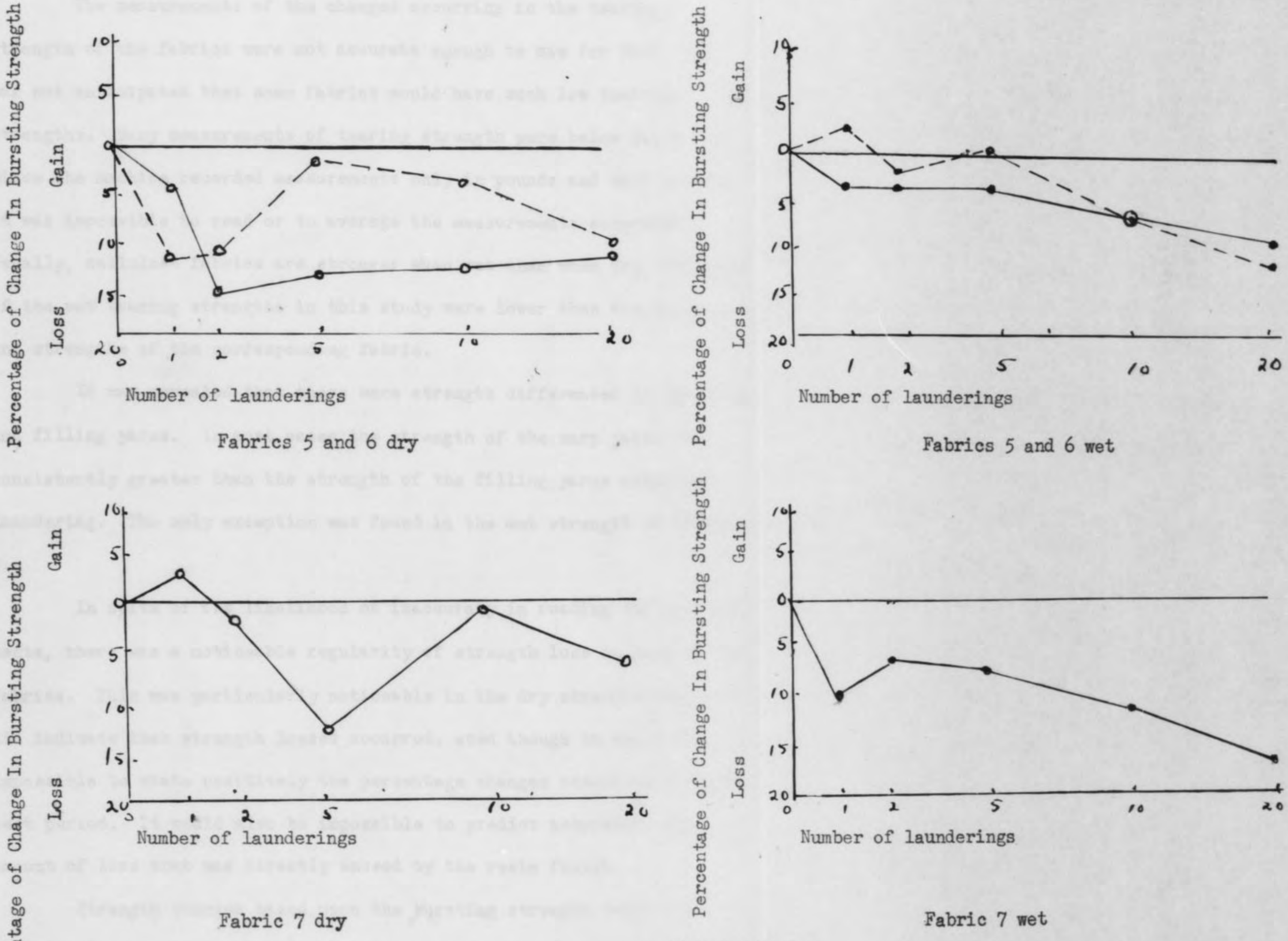


Figure 4 - Percentage of Change In Bursting Strength After Laundering



— Treated fabric
- - Untreated fabric
• Wet test
o Dry test

Figure 4 - Percentage of Change in Bursting Strength After Laundering

Changes in Tear Strength Occurring After Laundering

The measurements of the changes occurring in the tearing strength of the fabrics were not accurate enough to use for data. It was not anticipated that some fabrics would have such low tearing strengths. Many measurements of tearing strength were below one pound. Since the machine recorded measurements only in pounds and half pounds, it was impossible to read or to average the measurements accurately. Usually, cellulose fabrics are stronger when wet than when dry, but some of the wet tearing strengths in this study were lower than the dry tearing strengths of the corresponding fabric.

It was revealed that there were strength differences in the warp and filling yarns. In most cases the strength of the warp yarns was consistently greater than the strength of the filling yarns after each laundering. The only exception was found in the wet strength of fabric 7.

In spite of the likelihood of inaccuracy in reading the measurements, there was a noticeable regularity of strength loss in many of the fabrics. This was particularly noticeable in the dry strength tests and did indicate that strength losses occurred; even though it would be impossible to state positively the percentage changes occurring at each test period. It would also be impossible to predict accurately the amount of loss that was directly caused by the resin finish.

Strength changes based upon the bursting strength tests were considered more accurate, and all judgments of strength changes were based on this test. Measurements of the tearing strength tests are recorded in Tables XI and XII.

TABLE XI

Changes in Dry Tearing Strength Occurring After Laundering And Wear
(in pounds)

Fabric	1		2		3		4		5		6		7	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Original fabric	1.9	1.4	1.8	1.2	7.4	7.0	7.3	4.8	1.3	1.0	1.3	0.9	3.8	1.7
After 1 laundering	1.4	0.9	1.7	1.3	8.2	7.8	7.2	4.5	1.2	1.5	0.8	0.6	1.9	1.3
After 2 launderings	1.3	1.1	1.5	0.8	8.1	7.5	6.8	4.3	1.1	1.4	1.0	0.6	1.3	0.9
After 5 launderings	1.7	1.1	1.0	0.9	8.0	7.8	6.7	3.8	0.9	1.3	0.8	0.7	1.3	0.8
After 10 launderings	1.4	0.9	1.5	0.8	7.8	7.2	6.3	4.2	0.9	1.1	0.8	0.7	1.1	0.9
After 20 launderings	1.4	0.8	1.1	0.7	7.6	7.0	5.5	4.2	0.9	1.5	0.6	0.5	0.9	0.7
Dress specimens	1.2	0.9	1.3	0.8	5.4	5.6	6.3	4.3	0.8	1.0	0.9	0.6	0.9	0.9

TABLE XII

Changes in Wet Tearing Strength Occurring After Laundering And Wear
(in pounds)

Fabric	1		2		3		4		5		6		7	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Original fabric	1.8	0.6	2.0	1.6	9.1	8.8	18.0	10.7	2.2	1.0	0.6	0.3	0.8	1.3
After 1 laundering	1.3	0.5	2.4	1.5	11.3	9.3	17.0	9.8	1.8	0.9	0.7	0.3	0.6	1.1
After 2 launderings	1.2	0.7	2.1	1.3	9.9	9.3	14.3	9.7	1.4	1.0	0.8	0.1	1.3	1.2
After 5 launderings	1.3	0.4	2.3	1.3	10.0	9.0	9.3	8.7	1.6	1.5	0.7	0.2	1.0	1.1
After 10 launderings	1.5	0.7	2.2	1.3	8.9	8.6	13.3	9.8	1.2	1.1	0.4	0.3	0.9	1.0
After 20 launderings	1.0	0.3	1.9	0.8	9.3	8.2	11.3	10.0	1.1	0.9	0.3	0.2	1.0	0.4
Dress specimens	0.8	0.3	0.4	0.6	3.2	3.7	6.0	4.7	0.3	0.3	0.5	0.6	0.8	1.4

Changes in Crease Resistance Occurring After Laundering

There are several factors which would affect the angle of recovery from creases other than the amount of resin impregnated within the fiber and fabric. Variations in the fibers, in the yarns, and in fabric construction would be reflected in the crease resistance of a fabric. These variations would also influence the amount of resin absorbed by a treated fabric. As changes in dimensions occur, there could be expected to be a corresponding change in the recovery angle of fabrics from creasing.

The recovery angle of the untreated fabrics in their original state varied from 65.6 to 80.5 degrees in the warp and from 75.4 to 91.5 degrees in the filling direction. In the treated fabrics, the range of measurements was from 80.0 to 97.2 degrees in the warp and from 86.0 to 138.6 degrees in the filling direction. In all cases, the treated fabrics had a higher angle of recovery than did the untreated fabrics of the same construction. All of the treated fabrics except fabric 2 had a greater angle of recovery than 90 degrees, the recovery angle considered adequate for consumer use. Fabric 2 had a recovery angle of 80.0 degrees in the warp and 86.0 degrees in the filling. The recovery angle of fabric 6 in the warp direction was only 88.6 degrees, but the filling recovery angle was 94.8 degrees, making the mean recovery angle of the fabrics above 90 degrees. In all cases, there was a greater angle of recovery in the filling direction of the fabrics than in the warp direction. Fabric 4, the denim, had the greatest recovery angle of all the fabrics - 97.2 degrees in the warp and 138.6 degrees in the filling.

After laundering there was a change in the anti-wrinkling properties of all the fabrics. Fabric 1 had 3.6 per cent less recovery in the warp and 4.1 per cent more recovery in the filling direction. The treated fabric of the same construction had 3.5 per cent less recovery in the warp and 4.1 per cent less recovery in the filling. The angle of recovery was greater in fabric 2 than in fabric 1 by 12.6 degrees in the warp and 7.6 degrees in the filling. Fabric 3 suffered a loss in recovery angle of 1.6 degrees in the warp and 1.1 degrees in the filling direction. This was a loss of 2.4 per cent in the warp and 0.1 per cent in the filling. The loss occurring in fabric 4 after one laundering was 3.5 per cent in the warp and 11.8 per cent in the filling. The percentage of loss was greater in the treated fabric, but this fabric maintained a much higher level of crease resistance than did the untreated fabric. The angle of recovery of fabric 3 was 64.0 degrees in the warp and 90.4 degrees in the filling as compared to the recovery angle of fabric 4 of 93.8 degrees in the warp and 122.2 degrees in the filling. The same trends were evident in fabrics 5 and 6. A greater percentage loss occurred in the treated fabric than in the untreated, but a greater resistance to creasing was maintained in the treated fabric. Fabric 7 had the highest percentage loss of all the fabrics. The recovery angle was 15.1 per cent less in the warp and 15.0 per cent less in the filling direction. After one laundering all of the treated fabrics except fabric 4 had average recovery angles that were less than the 90 degrees desirable for consumer satisfaction.

In fabric 4, there was a progressive decrease in the recovery angle throughout all the launderings. In other fabrics, there was some fluctuation of measurements. After 20 launderings, a definite loss in anti-wrinkling properties of all fabrics was evident. In comparison to the original fabrics, fabric 1 lost 6.8 per cent in the warp and 8.7 per cent in the filling direction, and fabric 2 lost 2 per cent in the warp and 2.8 per cent in the filling. The recovery angle was greater in the treated fabric than in the untreated fabric by 15.6 degrees in the warp and 12.0 degrees in the filling direction. Fabric 3 had a recovery angle of 57.6 degrees in the warp and 90.0 degrees in the filling. This was a percentage loss of 12.2 per cent in the warp and 1.6 per cent in the filling. Fabric 4 had a recovery angle of 89.4 degrees in the warp and 117.6 degrees in the filling direction. The percentage loss occurring in this fabric was 8.1 per cent in the warp and 15.1 per cent in the filling. Fabric 5 had a recovery angle of 70.7 degrees in the warp and 72.3 degrees in the filling, a loss of 15.2 per cent in the warp and 4.1 per cent in the filling. Fabric 6 had a recovery of 80.3 degrees in the warp and 83.0 degrees in the filling, a loss of 9.4 per cent in the warp and 12.5 per cent in the filling. In this case, the treated fabric 6 had a smaller percentage loss than did the untreated fabric 5. After 20 launderings, fabric 7 had lost a greater percentage of anti-creasing properties than any other fabric. This loss was 13.0 per cent in the warp and 15.4 per cent in the filling. The recovery angle of fabric 7 was 82.8 degrees in the warp and 80.8 degrees in the filling.

All treated fabrics had greater crease resistance in the original state than did the untreated fabrics of the same construction. A greater recovery angle occurred in the filling direction of both treated and untreated fabrics than occurred in the warp direction. Of all the treated fabrics in the original state, fabric 2 was the only one having a smaller recovery angle than the desired 90 degrees. After the first laundering, all fabrics lost some anti-wrinkling properties. This loss was most likely caused by the removal of surplus resin in the treated fabrics and sizing in the untreated fabrics during the laundering process. Increases of recovery angle in some directions of the untreated fabrics could be attributed to variations in the yarns measured or to fabric changes caused by shrinkage or stretch. Measurements fluctuated throughout the launderings, but after 20 launderings evident losses of crease resistance had occurred. All fabrics had lower recovery angles, but the recovery angles of the treated fabrics were greater than those of the untreated fabrics of the same construction. Greater losses had occurred in the filling direction than had occurred in the warp direction of the fabrics. The percentage loss was not consistently greater or smaller with either the treated or untreated fabrics. Of the treated fabrics, only fabric 4 retained a desirable amount of crease resistance after 20 launderings. There was no consistent point at which the greatest change in crease resistance occurred. Instead, this point of change seemed to vary from fabric to fabric.

It can be concluded that the resin treated fabrics did better resist wrinkles throughout the twenty laboratory launderings. After 20 launderings, the crease resistance retained in the fabrics was less than the desired amount but greater than that of untreated fabrics of the same construction. The amount of crease resistance produced and retained in treated fabrics must be influenced by the construction of the fabrics or by the process of resin impregnation employed by the manufacturer.

Measurements of the recovery angles of all fabrics are recorded in Table XIII. Graphical comparisons of the percentages of change occurring in treated and untreated fabrics after laundering are presented in Figure 5, page 78.

TABLE XIII

Changes in Crease Resistance Occurring After Laundering And Wear
(in degrees)

Fabric	1		2		3		4		5		6		7	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Original fabric	67.4	78.4	80.0	86.0	65.6	91.5	97.2	138.6	80.5	75.4	88.6	94.8	95.2	95.5
After 1 laundering	65.0	81.6	77.2	82.5	64.0	90.4	93.8	122.2	83.4	74.8	84.8	91.5	80.8	81.2
After 2 launderings	75.6	68.8	78.8	81.2	64.4	90.0	94.4	120.4	83.5	74.0	87.4	96.8	88.2	89.8
After 5 launderings	73.6	76.4	77.6	78.4	61.8	88.4	97.4	119.8	61.5	72.0	86.5	94.0	87.8	85.2
After 10 launderings	67.5	59.0	80.2	88.0	61.6	90.0	95.0	117.2	65.2	62.4	85.2	91.8	77.6	91.4
After 20 launderings	62.8	71.6	78.4	83.6	57.6	90.0	89.4	117.6	70.7	72.3	80.3	83.0	82.8	80.8
Dress specimens	63.8	72.4	78.0	82.0	61.4	88.0	90.0	114.8	72.0	67.0	83.0	75.0	75.2	86.8

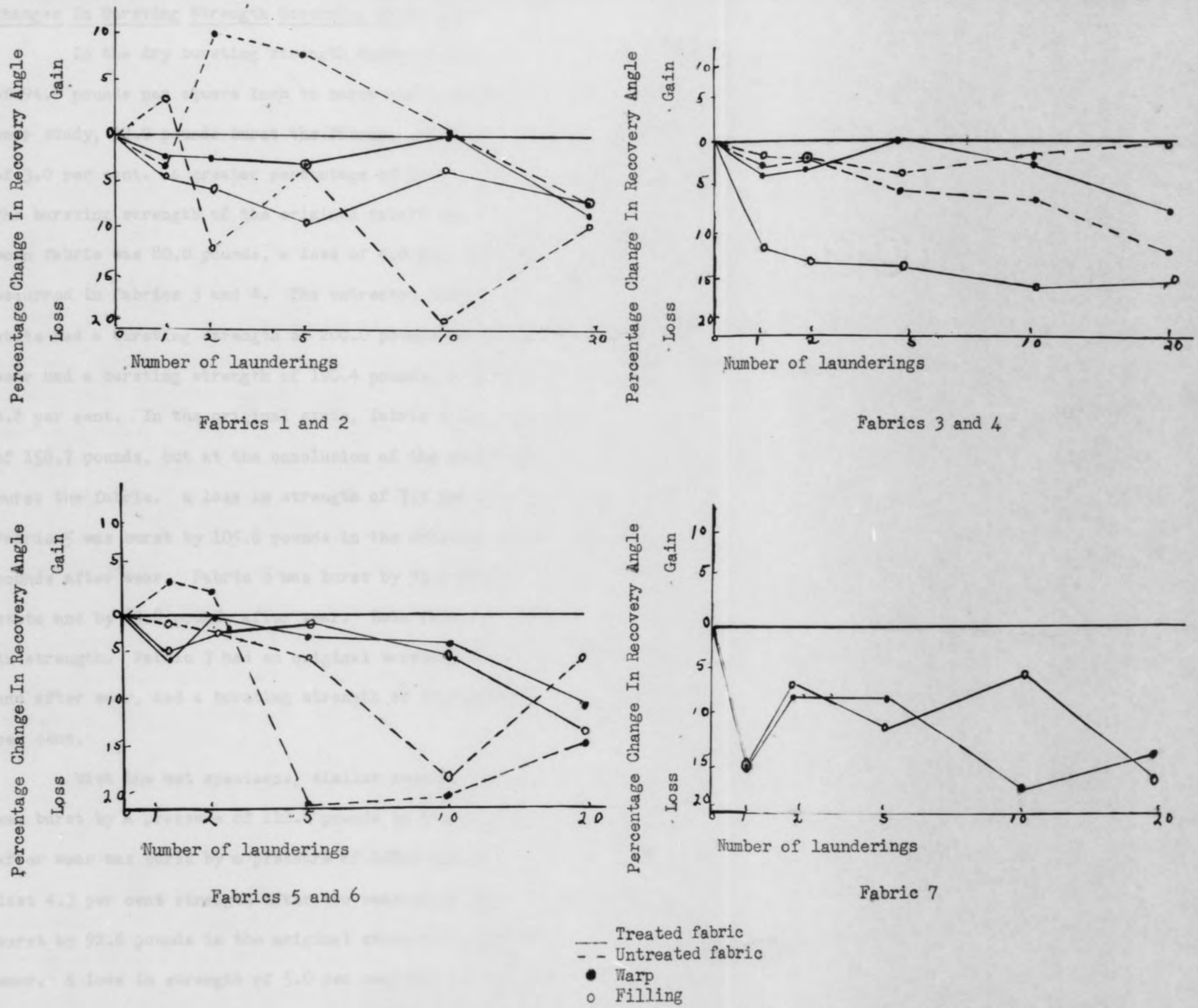


Figure 5 - Percentage of Change In Recovery Angles of Fabrics After Laundering

LABORATORY TESTS TO DETERMINE PHYSICAL CHANGES OCCURRING IN DRESS FABRICS

Changes In Bursting Strength Occurring After Wear

In the dry bursting strength tests, fabric 1 required a pressure of 94.8 pounds per square inch to burst the original fabric. After the wear study, 92.0 pounds burst the fabric. This was a loss in strength of 3.0 per cent. A greater percentage of loss occurred in fabric 2. The bursting strength of the original fabric was 83.3 pounds and of the worn fabric was 80.0 pounds, a loss of 4.0 per cent. Similar losses occurred in fabrics 3 and 4. The untreated fabric 3 in the original state had a bursting strength of 200.0 pounds and after two seasons of wear had a bursting strength of 190.4 pounds, a loss in strength of 4.8 per cent. In the original state, fabric 4 was burst by a pressure of 158.7 pounds, but at the conclusion of the wear study 147.0 pounds burst the fabric. A loss in strength of 7.4 per cent had taken place. Fabric 5 was burst by 105.6 pounds in the original state and by 97.3 pounds after wear. Fabric 6 was burst by 91.0 pounds in the original state and by 83.8 pounds after wear. Both fabrics lost 7.9 per cent in strength. Fabric 7 had an original bursting strength of 81.2 pounds and after wear, had a bursting strength of 77.0 pounds, a loss of 5.2 per cent.

With the wet specimens, similar results occurred. Fabric 1 was burst by a pressure of 112.8 pounds in the original state, but after wear was burst by a pressure of 108.0 pounds. This fabric had lost 4.3 per cent strength after two seasons of wear. Fabric 2 was burst by 92.6 pounds in the original state and by 88.0 pounds after wear. A loss in strength of 5.0 per cent had taken place. It was impossible to determine the loss of strength occurring in fabric 3 as all measurements exceeded the 200 pounds recorded by the testing maching. The measurement of the original fabric 4 exceeded 200 pounds and after the wear study, the measurement of bursting strength was 185.0 pounds, an approximate loss of 7.5 per cent. Fabric 5 had an original bursting strength of 127.2 pounds and after wear had a bursting strength of 118.0 pounds. This was a loss of 7.2 per cent. Fabric 6 was burst by 103.6 pounds in the original state and by 95.2 pounds after the wear study. A loss of 8.1 per cent had occurred. Fabric 7 was burst by 96.0 pounds in the original state and by 84.4 pounds at the conclusion of the wear study. This fabric lost 12.1 per cent bursting strength.

With both wet and dry specimens, the bursting strengths of the original fabrics were greater in the untreated fabrics than in the treated fabrics - with the exception of the dry bursting strength of fabrics 5 and 6; in which case both fabrics had the same percentage of strength loss. Since the treated and untreated fabrics were of the same construction, the smaller bursting strength of the treated fabrics and the greater loss of strength in the treated fabrics after wear must be attributed to the presence of the resin finish. The decreases in strength of the treated fabrics were not of sufficient amount to cause any appreciable change in the wearing qualities of the fabrics.

Measurements of the bursting strengths of the original fabrics and of the dress specimens are included in Tables IX and X, pages 65 and 66.

Changes in Tear Strength Occurring After Wear

The measurements of the tearing strengths of the fabrics were not accurate enough to use for data; so all strength changes were judged by the bursting strength tests. However, measurements of the tearing strength of the original fabrics and of the worn dress specimens are presented in Tables XI and XII, pages 70 and 71.

Changes in Crease Resistance Occurring After Wear

Fabric 1 had a recovery angle of 67.4 degrees in the warp and 78.4 degrees in the filling. After two seasons of wear, the recovery angle was 63.8 degrees in the warp and 72.4 degrees in the filling direction. A loss in anti-wrinkling properties of 5.3 per cent in the warp and 7.7 per cent in the filling had taken place. The recovery angle of fabric 2 had decreased from 80.0 to 78.0 degrees in the warp and from 86.0 to 82.0 degrees in the filling. This was a loss of 2.5 per cent in the warp and 4.7 per cent in the filling. Fabric 3 had an original recovery angle of 65.6 degrees in the warp and 91.5 degrees in the filling. At the conclusion of the wear study, the recovery angle was 61.4 degrees in the warp and 88.0 degrees in the filling, a loss of 6.4 per cent in the warp and 3.8 per cent in the filling. In the original state, fabric 4 had a recovery angle of 97.2 degrees in the warp and 138.6 degrees in the filling. After two seasons of wear, the angle of recovery was only 90.0 degrees in the warp and 114.8 degrees in the filling. Losses of 7.4 per cent had occurred in the warp and 17.9 per cent in the filling direction. The recovery angle of fabric 5 decreased from 80.5 degrees to 72.0 degrees in the warp and from 75.4 degrees to 67.0 degrees in the filling. The loss occurring in the warp was 10.6 per cent and in the filling was 11.1 per cent. Fabric 6 had an original recovery angle of 88.6 degrees in the warp and 94.8 degrees in the filling. The final recovery angle was 83.0 degrees in the warp and 65.0 degrees in the filling, a warp loss of 6.4 per cent and a filling loss of 21.4 per cent. The warp recovery angle of fabric 7 decreased from 95.2 degrees to 75.2 degrees and the filling recovery angle decreased from 95.5 degrees to 86.8 degrees. The percentage of loss occurring in the warp was 21.1 per cent and in the filling was 9.2

per cent.

The resin treated fabrics retained a greater resistance to wrinkling than did the untreated fabrics. After 2 seasons of wear, the angle of recovery of all fabrics was less than the desired amount except in fabric 4. However, the angle of recovery of all treated fabrics was superior to that of the untreated fabrics. The amount of crease resistance retained after wear varied with the treated fabrics. This variation could be attributed to differences in fabric construction or to differences in the methods of resin treatment used for each fabric.

Measurements of the recovery angle of the original fabrics and of the worn dress specimens are included in Table XIII, page 77.

Comparison of Wear Study and Laboratory Study

The results of the wear and laboratory tests were compared to determine the similarity of the results obtained by each.

The wearers of the garments detected no change in fit or fabric dimensions throughout the study. However, laboratory tests revealed that considerable changes in dimensions occurred after the first laundering; and after 20 launderings, there were varying amounts of dimensional change in the fabrics. In the treated fabrics, there was no percentage of change great enough to be detected during wear, but the changes occurring in some of the untreated fabrics would affect fabric serviceability. It is surprising that the wearer of garment 4 did not detect a change in fit of the portion of the garment constructed from fabric 5. This fabric shrank 3.4 per cent in the warp and 3.6 per cent in the filling. The wear study indicated that all fabrics were dimensionally stable, but the laboratory tests indicated the treated fabrics were of much greater stability than the untreated fabrics.

No changes in strength were reported in the wear study. Fabric 3 did show indications of wear, but no weakening of fabric was reported. The laboratory tests revealed that all original untreated fabrics had greater strength than did the original treated fabrics and that a greater percentage of strength was lost in the treated fabrics than in the untreated fabrics. Laboratory tests of the worn dress fabrics corroborated the decreased amount of strength that was present in treated fabrics and the greater loss of strength that occurred in the treated fabrics after wear and laundering. However, the losses of strength that occurred in the worn dress specimens was not as great as those occurring in the specimens that were laundered 20 times in the laboratory. Since no dress fabric had been laundered more than nine times, this result was not surprising. No strength loss was great enough to affect the fabric wearing properties, so it is not surprising that the decreased strength of the treated fabrics was not detected during the wear study.

The wearers of the garments were able to detect the presence of a crease resistant finish in all the treated fabrics other than fabric 2. The laboratory tests of this fabric showed that the amount of crease resistance was less than the desired amount but greater than the amount present in the untreated fabric of the same construction.

After one season of wear, all of the treated fabrics were more resistant to wrinkling than were the untreated fabrics of the same construction. Changes in hand were reported to have occurred in all fabrics and were verified by the laboratory tests. The final report of garment serviceability revealed that in the treated fabrics a greater softening of hand and a greater loss of anti-creasing properties had occurred. The wear record of fabric 2 reported very few changes throughout the study. Laboratory tests of this fabric showed some loss of recovery angle; but at all times the recovery angle was low, and at the conclusion of the study was low enough in this fabric and the untreated control that a great amount of wrinkling would occur in both. The wearer of the garment containing fabric 3 and 4 could still detect the difference in the wrinkling tendencies of the two fabrics. Laboratory tests showed that fabric 4 did have a greater recovery angle than fabric 3 at the conclusion of the wear study. In fact, fabric 4 was the only treated fabric that retained a desirable amount of crease resistance at the conclusion of the study. The wearer of the garment containing fabrics 5 and 6 thought that both fabrics had reached the point that the same amount of wrinkling occurred in each. Laboratory tests showed a ten degree difference in the recovery angle of fabrics 5 and 6, but tests of the dress specimen showed a difference of only 8 degrees. This was similar enough that the wearer could not be expected to notice the difference.

The loss of crease resistance after wear and laundering was determined in the wear and the laboratory tests. In some cases, the worn fabric had greater crease resistance than the laboratory laundered specimen. In other cases, the dress specimen had less crease resistance than the laboratory laundered specimen. So there was a variation in fabric as to whether more crease resistance was lost during wear or laboratory tests. Some variation could have been caused by variations in conditions of wear. In most cases, the measurements determined by the two test methods were similar.

The loss of strength and the decreased amount of strength present in treated fabrics was not detected in the wear study. Nor were changes in dimensions observed in the wear study. Changes in dimensions and strength did occur and were determined by the laboratory tests. The loss of anti-creasing properties were detected in wear and in laboratory tests.

CHAPTER V

SUMMARY OF RESULTS AND SUGGESTIONS FOR FURTHER STUDY

This study was undertaken for the purpose of determining the serviceability of certain fabrics which had been treated with resins to produce crease resistance. Four treated fabrics and three untreated fabrics were selected for the study. The construction of each untreated fabric corresponded to that of one of the treated fabrics. The fabrics were made into garments and subjected to usual wear conditions. The adaptability of the fabrics to garment construction and the serviceability of the fabrics obtained during wear were reported by persons cooperating with the wear study. Test specimens of the fabrics were subjected to laboratory laundering. One specimen of each fabric was removed after the first, second, fifth, tenth, and twentieth launderings so that changes in dimensions, bursting strength, tear strength, and crease resistance might be determined at each stage. Similar laboratory tests were made of dress specimens at the conclusion of the wear study.

Results of the study showed that there were differences in the durability of the fabrics and in the effectiveness or permanence of the finish. Few of the changes in fabric properties were of sufficient amount to be of great concern to the consumer during wear. The results of the analysis of the factors that would be of greatest interest to users of such fabrics are discussed in the following paragraphs.

Analysis of Original Fabric Construction

The laboratory analysis of the original fabrics revealed that the untreated fabrics and the corresponding treated fabrics were of practically identical construction. Differences between the sets of fabrics were attributed to the variations in construction of fabrics of different types rather than to the presence or absence of a resin finish.

Adaptability of the Fabrics to Garment Construction

All of the treated fabrics other than fabric 2 were described as having a harsher and stiffer hand than the corresponding untreated fabrics. The presence of a crease resistant finish was detected in all treated fabrics except fabric 2. This indicated that fabric 2 either had a small amount of crease resistance or that the crease resistance present did not bring about the same changes in hand as were produced in the other resin treated fabrics. Subsequent tests revealed that this fabric did not have a satisfactory amount of crease resistance.

In spite of the stiffer hand that was present in the treated fabrics, the persons who made the garments did not report a great amount of difficulty in handling the fabrics. Fabrics 3 and 4 did not respond satisfactorily to the elimination of fullness. With all other fabrics, no problems were encountered in the elimination of fullness or in the formation of pleats. However, it is doubtful that fabrics 3 and 4 would have responded to pleating satisfactorily if pleats had been used. The difficulty of handling the treated fabrics was undoubtedly minimized by the choice of simple designs which did not provide the opportunity for the fabrics to offer their full potentialities for problem making.

The adaptability of the fabrics to garment construction also seemed to be influenced by the amount of resin absorbed by the fabrics.

The varying amounts of resin absorbed by the different fabrics could have been influenced by variations in fabric construction or by variables in the process of resin impregnation employed by the manufacturers.

Comparison of Original Crease Resistance and Strength Properties of Fabrics

In the original state, the treated fabrics had greater recovery angles from creasing than did the untreated fabrics of the same construction. The fabrics with greater resistance to creasing were found to have less bursting strength than the untreated fabrics. The resin finish which produced crease resistance must have caused a loss of strength in the treated fabrics.

Dimensional Stability

No changes in the fit of garments were observed by the wearers throughout the two seasons of wear, indicating that the fabrics were retaining their original dimensions insofar as could be ascertained by wear. Measurements of the fabrics after laboratory laundering revealed that changes in dimensions had occurred, the greatest single change occurring after one laundering. After the second laundering, the dimensions were nearer those of the original fabrics. Thereafter, there was a gradual increase in the percentage of dimensional change occurring after each laundering. All treated fabrics had lower percentages of dimensional change than did the corresponding untreated fabrics. In no case was the dimensional change in the treated fabrics serious enough to impair the serviceability; but in the untreated fabrics, several changes were great enough to cause undesirable changes in garment fit. It can be concluded that resin treated fabrics have a greater dimensional stability than do untreated fabrics.

Bursting Strength

In both wet and dry bursting strength tests, the original untreated fabrics had a greater bursting strength than did the original untreated fabrics of corresponding construction. After laboratory laundering, a slightly greater percentage of loss occurred in the treated fabrics than occurred in the corresponding untreated fabrics. The percentages of strength loss occurring after laundering were similar in the treated and untreated fabrics, but the treated fabrics had a smaller bursting strength throughout the study than did the corresponding untreated fabrics. The same trends were established in the laboratory tests of the worn dress specimens; however, the loss of strength was greater in the laboratory tests than in the wear tests. Since no dress had been laundered more than nine times, this was to be expected. There were no reports of strength losses from the wearers; so the decreased strength of resin treated fabrics was not serious enough to impair the wearing qualities of the fabrics. The decreased strength of resin treated fabrics appears to result from the resin treatment.

Tearing Strength

This data was not analyzed as mechanical difficulties encountered during the tests made the accuracy of the data questionable.

Crease Resistance

All original treated fabrics had greater crease recovery angles than did the corresponding untreated fabrics. After laundering, the recovery angles were smaller in all fabrics, with the greatest loss occurring in the treated fabrics. However, after twenty laboratory launderings the treated fabrics retained a greater ability to recover from creasing than did the corresponding untreated fabrics. Only one resin treated fabric retained a satisfactory resistance to creasing after twenty laboratory launderings. The other resin treated fabrics had smaller recovery angles than the desirable amount, but greater recovery angles than the corresponding untreated fabrics. There was no common point at which the greatest loss in recovery angle occurred. Instead, the amount of loss and the point of greatest loss seemed to vary with the fabrics. The same pattern of loss of crease resistance was disclosed by laboratory testing of the worn dress specimens and from the reports of the wear study.

Serviceability of Fabrics as Determined by the Wear Study

The garments constructed of the resin treated fabrics had little tendency to wrinkle and the wrinkles that occurred disappeared after hanging. Some softening of hand resulted after the first laundering and was probably caused by the removal of surplus resin. After two seasons of wear, there was little indication of crease resistance in most of the fabrics. There was no indication of dimensional changes or loss of strength in any of the fabrics. One fabric did show signs of wear. The resin treated fabrics ironed smoothly and more easily than did the untreated fabrics.

Serviceability of Fabrics as Determined by Laboratory Testing

The resin treated fabrics had a greater resistance to wrinkling throughout the life of the garments than did the untreated fabrics of corresponding construction. However, a marked loss in crease resistance occurred upon laundering and wear. At the conclusion of the study, only one resin treated fabric retained a desirable amount of crease resistance.

The treated fabrics had greater dimensional stability, but smaller bursting strength than that of the untreated fabrics. The decreased amount of strength in the treated fabrics was not serious enough to impair the wearing qualities of the fabrics. This investigation revealed that the application of crease resistant finishes to cotton fabrics did warrant the extra cost accompanying such fabrics. The consumer could detect the presence of this finish and did realize some benefits from the treatment. There was less wrinkling and a greater tendency to recover from wrinkles in treated fabrics. Even though most of the resistance to wrinkling was lost after two seasons of wear, the improved serviceability of the fabrics during this period was of sufficient value to justify the finish. The treated fabrics had greater dimensional stability, so there would be little or no chance of noticeable shrinkage occurring. Although there was some loss of strength, it was not great enough to be reflected during wear. The fabrics offered only minor problems during construction, and these problems were more than compensated by the fresher and more attractive appearance of the fabrics during wear. Since no starching was required and the fabrics were easier to iron, there was a reduction of time and energy required to care for the garments.

It would be desirable to have treated fabrics that would retain their anti-wrinkling properties throughout the life of the garment; but until such fabrics are developed, the present treatments are valuable in producing fabrics that give better service during wear than do the easily wrinkled untreated fabrics.

Suggestions for Further Study

The treated fabrics of this study varied considerably in the amount of crease resistance retained after wear and laboratory testing. The same variations occurred in dimensional changes and in bursting strength properties. It would be valuable to determine the exact relationship of variations in fabric construction, the amount of resin absorbed by various constructions, and the changes in fabric properties that result with varying constructions. It would also be of interest to determine the effect of various methods of resin impregnation upon fabric serviceability, a result which could be obtained by controlling the fabric construction.

One fabric of this study showed indications of wear. The wear was thought to result from abrasive action that was encountered during wear. A study to compare the abrasion resistance of treated and untreated fabrics would be desirable.

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APPENDIX

REPORT ON GARMENT CONSTRUCTION

Garment Number__________________ Date of Report ________________

Name of Person Reporting ____

Please complete this report and return it to the laboratory as soon as the garment has been finished.

1. How do you like the weight of this material for the type of garment selected?

   Too heavy __________
   Satisfactory _______
   Too light __________

2. What is your opinion of the hand or "feel" of the material? Underline the adjective which might describe your opinion.

   Harsh, coarse, soft, fine, smooth, scratchy, stiff, flimsy

3. Is it easily apparent that a crease resistant finish has been used on this fabric?

   Yes _____ No _____

4. Were unusual problems encountered during construction?

   Yes _____ No _____

   Explain ____

5. How did the fabric respond to the elimination of excessive fullness?

   ____

6. How did the fabric respond to pleating?

   ____

7. In general would you say that the material was:

   _____1. Easy to handle?
   _____2. Difficult to handle?

DIRECTIONS FOR WEARING GARMENTS

Crease resistance is a popular subject to those of us who wear cotton, linen, and rayon garments. This research project has been planned to study the crease or wrinkle resistance properties of selected fabrics. Your cooperation will involve wearing the garments and recording any changes which may occur as the fabric is worn and laundered.

Your observations are a necessary part of the study. If these directions are followed carefully, we should find results which will indicate the serviceability of crease resistant fabrics.

INSTRUCTIONS:

1. Wear the garment as you would wear any other garment of this type.

2. Note on the wear record:

   a. The number of hours of wear,
   b. Any unusual conditions of wear, and
   c. Any damage to the fabric or garment.

3. Launder the garment as you would launder any garment of this type.

4. Note on the wear record:

   a. The date of each laundering,
   b. Any changes you notice in the fabric or fit of the garment after laundering.

5. Fill in the report blanks as they are mailed to you and return them promptly.

6. Return the garment and wear record to the laboratory after the fifth laundering.

WEAR RECORD

FABRIC NUMBER ________________ GARMENT NUMBER ________________

ISSUED TO ____

DATE	NUMBER OF HOURS WORN	COMMENTS

LAUNDERING RECORD

DATE	COMMENTS

FIRST REPORT BLANK

WEARER ______________________________ GARMENT NUMBER __________

ADDRESS ______________________________

Date of report ________________________

1. How did the garment fit before laundering? ____________________

   ____

2. How would you describe the fabric before laundering?

   Stiff ____ Soft ____ Smooth ____ Rough ____ Scratchy ______

3. How was the garment laundered?

   a. Hand washing ____

   b. Machine washing at home ____

      What type of machine was used? ____________________

   c. Commercial laundering ____

      Name of laundry ______________________________

4. What was the approximate temperature of the water used?

   Very hot ____ Moderately hot ____ Lukewarm ____

5. What soap or detergent was used? ____________________

6. Did the fabric iron easily? ____________________

7. Did you notice any change in the fit of the garment after laundering? ______________________________

8. Did you notice any change in the "feel" of the fabric after laundering? ______________________________

9. How does the fabric react to creasing or wrinkling?

   a. Wrinkles easily __________ b. Little creasing or wrinkling ________ c. Crease and wrinkles disappear after hanging ______________________________

10. Any further comments on the fabric or the fit of the garment ____

    ____

FIRST LABORATORY REPORT BLANK

Garment Number ______________________________ Date ______________

1. Number of times laundered ______________________________

2. Apparent differences in the feel of the fabric ______________

    No change ______________________________

    Softer than original fabric ______________________________

    Less body than original fabric ______________________________

3. Apparent changes in color ______________________________

    Explain changes ______________________________

4. Classification of color changes ______________________________

5. Indication of wear ______________________________

    Description ______________________________

    Location ______________________________

    Cause ______________________________

SECOND REPORT BLANK

WEARER ______________________________ GARMENT NUMBER ________

ADDRESS ______________________________ DATE ______________

1. How many times has the garment been laundered? ______________

2. Has the method of laundering differed from that first used? _____
   If so, describe the
   (1) method ______________________
   (2) approximate temperature ______________
   (3) soap or detergent used ______________

3. Have you noticed any changes in the fit of the garment? ________

   ____

   ____

   ____

4. Have you noticed any changes in the texture or "feel" of the fabric?

   ____

   ____

   ____

5. Have you noticed any signs of wear in the fabric? ____________

   ____

   ____

   ____

6. Have you noticed any changes in the crease or wrinkle resistance of the fabric?

   ____

   ____

   ____

SECOND LABORATORY REPORT BLANK

Garment Number ______________________________ Date ___________________

1. Number of times laundered ____

2. Apparent differences in the feel of the fabric ___________________

   No change ____

   Softer than original fabric ______________________________________

   Less body than original fabric ___________________________________

3. Apparent changes in color ____

   Explain changes ____

4. Classification of color changes __________________________________

5. Indication of wear ____

   Description ____

   Location ____

   Cause ____